1984 NASA AUTHORIZATION

HEARINGS

BEFORE THE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

FIRST SESSION

FEBRUARY 3, 8, 10, 22, 23, 24, 25, 26, 28; MARCH 1, 2, 3, 1983

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1984 NASA AUTHORIZATION

THURSDAY, FEBRUARY 3, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
Washington, D.C.

The committee met, pursuant to call, at 2:05 p.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the committee) presiding.

Present: Mr. Fuqua, Mr. Brown, Mr. Harkin, Mr. Glickman, Mr. Volkmer, Mr. Nelson, Mr. Hall, Mr. Mineta, Mr. Durbin, Mr. Andrews, Mr. MacKay, Mr. Valentine, Mr. Reid, Mr. Lujan, Mr. Walker, Mr. Carney, Mr. Sensenbrenner, Mr. McGrath, Mr. Skeen, Mr. Chandler, Mr. Bateman, and Mr. McCandless.

Mr. FUQUA. The committee will be in order.

This afternoon the committee begins our review of the NASA fiscal year 1984 budget request. We want to welcome once again the NASA Administrator, James Beggs, and the Deputy Administrator, Dr. Hans Mark, and look forward to their presentation of the 1984 budget.

Considering the Nation's budget situation we must look very positively on the budget level which has been proposed. However, there are concerns both with regard to program balance between space flight activities and space science, applications, and aeronautics activities and with regard to the balance of program thrust between civil and military activities. We are pleased that the administration has adopted congressional redirection of the NASA planetary, aeronautics and advanced satellite communications programs, but are somewhat less than pleased by NASA's failure to address program augmentations in materials processing and advanced upper stage activities.

NASA's response to our recent communications concerning these issues and the NASA DOD shuttle pricing policy issue could probably best be characterized as less than responsive. In the past few years concerns have been raised in the press and in the Congress with regard to the appropriate relationship between NASA space activities and those of the national security establishment. The National Aeronautics and Space Act of 1958 provides for separate civil and defense programs with, however, shared information in technology, shared launch vehicles, and where appropriate, cooperative programs.

Increased emphasis on technology sharing and increasing coordination of budget issues dictate that Congress increase its scrutiny of these relationships to insure that the interest of the civil space programs are protected. NASA's programs can play a positive role

in expanding scientific knowledge and stimulating students to pursue science and engineering careers. Our civil space activities also make positive contributions to our Nation's economy through increased productivity and innovation as well as development of new industries. We as a Nation must continue to make the investment necessary to strengthen and increase commercial aerospace sales, through exportation of space and aeronautical technology. The existence of the open space and aeronautics programs conducted by NASA contributes significantly to this end.

At this time I would like to insert in the record a statement by Mr. Winn, who was unable to be here today, and call on Mr. Volkmer for any comments that he may wish to make.

[The opening statements of Mr. Winn and Mr. Carney follow:]

STATEMENT OF HON. LARRY WINN, JR.

Thank you, Mr. Chairman. I join with you in welcoming Jim Beggs and Hans Mark to the Committee today, and I look forward to their testimony that will highlight NASA's budget posture for 1984.

The $7.1 billion request by NASA represents a 4 percent increase over the current appropriated budget, and a 7.5 percent increase over the fiscal year 1983 Administration request. I am pleased to see that with this increase, NASA will reemphasize their activities in space technology, physics and astronomy, and aeronautical research and technology.

I am especially pleased to see the increase in Aeronautical R&D. This represents an increase of over 7 percent and reflects a strong commitment to maintaining our leadership in aeronautical technology. I know this budget will disappoint some who have wanted an even greater federal role in civil aeronautics, but we must recognize that this country faces severe economic times and we need to set priorities.

NASA is at a critical stage of transition for the Space Shuttle. The Columbia performed flawlessly in its first five flights, and despite some initial "shakedown" problems, the Challenger should join her sister ship in the STS fleet with a planned late-March launch date. The two operational orbiters are scheduled for five launches in 1983, and will carry a host of international and U.S. communications satellites, initiate the services of the Tracking and Data Relay System, and carry aboard the European-built Spacelab.

Approximately 60 percent of NASA's budget is earmarked for the Shuttle. The remainder of the monies are spread across various aeronautical and space areas at the civilian space agency in order to continue a number of activities in various programs, including: planetary exploration with International Solar Polar Mission, and Galileo orbiter and probe to Jupiter; 30/20 Gigahertz advanced communications satellite; technology utilization; and many more. I am also pleased to see that NASA intends to start several new initiatives this year in aeronautics and space. I believe that Mr. Beggs will describe these new initiatives in detail during his testimony.

I look forward to working with you and with our new colleagues on the Committee as we begin the fiscal year 1984 budget deliberations.

Thank you.

STATEMENT OF HON. WILLIAM CARNEY

Thank you, Mr. Chairman. I too want to welcome the gentlemen from NASA here today, and look forward to hearing their testimony on the NASA budget for 1984.

I also wish to second the remarks made by my colleague from Kansas, Mr. Winn, regarding the aeronautics budget. This budget is a reaffirmation of the aeronautics policy that was established last fall by the President's Office of Science and Technology Policy. It recognizes the important role that Aeronautics R&T plays in both the economic well being of the country, as well as in a strong national defense.

I particularly support the emphasis on computational research. The Numerical Aerodynamic Simulation, proposed as a new initiative for 1984, promises to be a real breakthrough in aeronautical research, and represents the kind of long term investment in aeronautics R&T that we need, and that I believe we can all support. I'm sure we'll be hearing more about this today.

Thank you.

Mr. VOLKMER. Thank you, Mr. Chairman. As the new chairman of the Subcommittee on Space Science and Applications, I would like to commend Chairman Fuqua and Mr. Winn for their leadership to our space program over many years. I look forward to working with them and with Mr. Lujan, the ranking minority member on the Space Subcommittee.

I share Chairman Fuqua's view that we must carefully scrutinize the relationship between NASA and the national security establishment to assure that the interests of our civil space program are protected. We must maintain and strengthen our space science and applications program to maintain U.S. technological leadership and provide maximum benefit not only to our own citizens, but to the world. I want to carefully review the issues related to increasing the orbiter fleet as well as increasing the shuttle flight rate capability.

I want to add my welcome to the witnesses today and I look forward to your testimony, Mr. Beggs.

Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Lujan.

Mr. LUJAN. I join with you and my colleagues in welcoming Mr. Beggs to the committee today. NASA appears to have fared better than many other Federal agencies with a 4-percent budget increase to keep pace with inflation. The civilian space agency now seems to be moving back to research and development. Since we are coming off the major development expenditures of the space shuttle and moving into the operational portion of the reusable space transportation system [STS], this should free up some of the moneys for other NASA programs that have suffered in the past because of the growing shuttle costs and delays. I believe they will describe these new starts in testimony.

As the new ranking Republican member on the subcommittee, I look forward to a productive legislative year working with NASA and my colleagues on the subcommittee. I also want to congratulate the new chairman of the Subcommittee on Space Science and Applications, Mr. Volkmer, for his selection of the aeronautics and space authorizing committee.

Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Lujan. Jim, we are happy to have you here once again, and will be looking forward to your testimony.

[A biographical sketch of Mr. Beggs follows:]

National Aeronautics and Space Administration

Washington, D.C. 20546

Biographical Data

JAMES M. BEGGS
Administrator, NASA

James Montgomery Beggs was nominated by President Reagan on June 1, 1981 to become Administrator of the National Aeronautics and Space Administration. He is the sixth man to head the nation's civilian space agency. Beggs took his oath of office as head of the agency and entered the new post on July 10, 1981.

Beggs had been Executive Vice President and a director of General Dynamics Corp., St. Louis, Mo.

He served with NASA in 1968-1969 as Associate Administrator, Office of Advanced Research and Technology. From 1969 to 1973, he was Under Secretary of Transportation. He went to Summa Corp., Los Angeles, Calif., as Managing Director, Operations and joined General Dynamics in January 1974. Before joining NASA, he had been with Westinghouse Electric Corp.,in Sharon, Pa., and Baltimore, Md., for 13 years.

A 1947 graduate of the U.S. Naval Academy, he served with the Navy until 1954. In 1955, he received a master's degree from the Harvard Graduate School of Business Administration.

A member of the Board of Governors of the National Space Club and the American Astronautical Society, his other professional affiliations include the National Academy of Public Administration, the American Institute of Aeronautics and Astronautics, the American Society of Naval Engineers and Sigma Tau.

He holds an honorary LL.D. degree from Washington and Jefferson College, Washington, Pa.; an honorary doctor of engineering management degree from Embry-Riddle Aeronautical University, Daytona Beach, Fla.; an honorary LL.D. from Maryville College in St. Louis, Mo.; an honorary doctor of science degree from the University of Alabama, and an honorary doctor of aeronautical science degree from Salem College.

Born in Pittsburgh, Pa., Jan. 9, 1926, Beggs and his wife, the former Mary Harrison, have five children. They make their home in Bethesda, Md.

# # #

January 1983

STATEMENT OF JAMES M. BEGGS, ADMINISTRATOR, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY DR. HANS MARK, DEPUTY ADMINISTRATOR; THOMAS NEWMAN, NASA COMPTROLLER; DR. BURTON I. EDELSON, ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS; S. NEIL HOSENBALL, GENERAL COUNSEL; ROBERT F. ALLNUTT, ACTING ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS; LT. GEN. J. A. ABRAHAMSON, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT; MR. R. E. SMYLIE, ASSOCIATE ADMINISTRATOR FOR SPACE TRACKING AND DATA SYSTEMS; DR. WALTER B. OLSTAD, ASSOCIATE ADMINISTRATOR FOR MANAGEMENT; DR. JACK L. KERREBROCK, ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY; AND SAMUEL W. KELLER, DEPUTY ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS

Mr. BEGGS. Thank you, Mr. Chairman. I have a written statement that I would like to submit for the record.

Mr. FUQUA. Without objection we will make the written statement in its entirety part of the record.

Mr. BEGGS. Thank you, Mr. Chairman. It is a pleasure for me to appear before this distinguished committee to present President Reagan's budget request for NASA for fiscal year 1984. The total request is $7.1 billion, of which $5.7 billion is for research and development, $150 million for construction of facilities, and $1.25 billion for research and program management. A chart summarizing NASA's fiscal year 1984 request is appended to my statement.

I am particularly proud to be at NASA in 1983 to celebrate its 25th anniversary. During the 25 years since the United States entered the space age, our space program has grown from the 14 kg Explorer, launched in January 1958, to a truly reusable space transportation system.

Mr. Chairman, I would like to spend a few minutes discussing some of the achievements of the past year—achievements which have been very significant, indeed, and which would not have been possible without the strong and continued support of the Congress. In 1982, the space shuttle orbiter *Columbia* made three successful orbital flights and, during each flight, significant progress was made in understanding the operational features of the shuttle system. This initial phase of the STS flight program culminated with the first operational flight in November 1982, during which two commercial communications satellites were launched. There is no doubt in my mind, Mr. Chairman, that the investment this Nation has made in the space shuttle will pay off handsomely. We now know enough about the system so that I can make this statement with great confidence.

A new Earth observation satellite, Landsat-4, was placed in Earth orbit in July 1982, and its operations have been spectacularly successful. The satellite's new thematic mapper has provided information of a quality exceeding the original specifications; it is providing valuable information for the geophysical sciences as well as excellent data for mapping and Earth resources assessment.

In aeronautics, the Department of Defense has recognized the importance of NASA's technical contributions by considering

NASA's tilt-rotor aircraft concept as a prime contender for the new joint service JVX vertical takeoff and landing aircraft program. Also, two large new aeronautical facilities are nearing completion, the National Transonic Facility at the Langley Research Center and the new 80- by 120-foot addition to the 40- by 80-foot subsonic wind tunnel at the Ames Research Center. The completion of operational test and checkout of the new 80- by 120-foot leg has recently suffered a setback because of an accident during testing. The facility is expected to be fully operational in about 2 years.

This is just a brief overview of a few of the technical achievements of 1982—the list is really much longer. I will talk in more detail about some of the things that have been accomplished later.

On July 4, 1982, President Reagan issued a policy statement which outlines basic U.S. goals for activities in space. These goals are: to strengthen the security of the United States; to maintain U.S. space leadership; to obtain economical and scientific benefits through the exploitation of space; to expand U.S. private sector investment and involvement in civil space and space-related activities; to promote international cooperative activities in the national interest; and, finally, to cooperate with other nations in maintaining freedom of space for activities which enhance the security and welfare of mankind.

The NASA budget request for fiscal year 1984, which I am addressing today, is designed to achieve the objectives outlined in President Reagan's space policy.

The key to leadership in space is to have efficient and effective ways of getting there. The President's space policy strongly supports the space shuttle program, and calls the shuttle "the primary space launch system for both U.S. national security and civil government missions."

NASA's proposed fiscal year 1984 budget fully supports a four-orbiter fleet, with enough structural and subsystem spares to make certain that the fleet is able to survive serious delays or accidents. Our proposal will also reduce the leadtime for replacement of the four-orbiter fleet, if and when operational demands require. NASA's first priority, Mr. Chairman, remains to make the space shuttle system fully operational as rapidly as possible. We will also continue to explore new ways of employing the full capability of the shuttle. Later on this year, we are scheduled to fly the first spacelab mission which is an important demonstration of the new capabilities represented by the space shuttle. The spacelab, developed and contributed by the European Space Agency, represents an important international activity consistent with the President's space policy.

NASA policy has recently been revised to expand opportunities for sponsors of shuttle payloads to nominate payload specialists to fly with them. President Reagan invited Brazilian, Japanese, Australian, and Canadian payload specialists to fly aboard the shuttle.

In my testimony before this committee last year, I said that the space telescope will be the most important scientific instrument we have ever flown. I continue to believe this is true, and NASA's fiscal year 1984 budget request provides priority support to this very important development effort.

As might be expected in a program of this complexity, we are continuing to experience certain difficulties, particularly in the optical telescope assembly development activities, which will most likely impact the scheduled launch and runout cost of the space telescope. We are currently reviewing a range of alternatives for rephasing the work to minimize the cost and schedule impact. As soon as our evaluation is complete, we will inform the committee of our proposed actions.

Another measure of leadership in space is the continuing enterprise of planetary exploration. We have included in the proposed fiscal year 1984 budget the initiation of a new program to map the entire surface of the planet Venus using radar imaging techniques. Within our overall strategy for planetary exploration, this initiative—the Venus radar mapper, estimated to cost in the $350 million range—replaces, at a lower cost, the Venus orbiting imaging radar mission authorized by the Congress to begin in fiscal year 1982.

The advanced communications technology satellite [ACTS] project calls for development and flight testing of the high-risk technology needed to insure continued U.S. preeminence in the field of satellite communications. The decision to propose the ACTS program is a result of extensive consultation with the communication carriers and satellite system suppliers, coupled with support from the Congress. The ACTS program will involve a novel procurement approach, including a cost/risk sharing arrangement with industry which will provide significant cost savings to the Government.

Another goal of the President's space policy is to expand private sector investment and involvement in space activities. NASA has received proposals from the private sector to fund and/or operate launch vehicles. We are reviewing these proposals very carefully to determine costs and benefits, launch and tracking requirements, safety and security, as well as international considerations.

In November 1982, the President's Office of Science and Technology Policy released a document entitled, "Aeronautical Research and Technology Policy." The aeronautics program included in NASA's fiscal year 1984 budget request reflects many recommendations contained in this important policy statement. The most important facet of the administration's new aeronautics policy is the recognition that a strong aeronautics industry is absolutely essential for both the national security and the health of our economy. In concert with this policy, we are submitting a fiscal year 1984 budget request which continues to emphasize a strong aeronautical research and technology program, including a strengthened fundamental research program which will continue to provide the technical base upon which future aircraft designs can be based.

The centerpiece of our proposed aeronautics program for fiscal year 1984 is the new numerical aerodynamic simulation [NAS] activity, which will be developed over the course of the next few years. The NAS capability will include a large computer system which will make it possible to perform most of the calculations required to design a new aircraft with sufficient accuracy and reliability to significantly reduce the long and expensive process of wind tunnel and flight testing now necessary. The investment

made in NAS will provide incentives for various elements of the computer industry to produce machines which will be able to take advantage of major commercial applications. Developments of this kind will enhance the competitive posture of the United States in this important international market.

In the fiscal year 1984 budget before you, there is a substantial increase in funding for construction of facilities—$150 million as compared to approximately $100 million in fiscal year 1983. We are also proposing the maintenance of the same number of civil service positions in fiscal year 1984 as we have in fiscal year 1983.

In the past year, Mr. Chairman, concern has been expressed in the press and in the Congress about the appropriate relationship between NASA and those elements of the national security establishment with responsibility for space operations. I would like to take this opportunity to state categorically that this administration is strongly committed to separate space programs, one dealing with civil sector operations and the other with those related to the national security. The President's space policy is very clear on this point, stating that,

> The United States space program will be comprised of two separate, distinct, and strongly interacting programs—national security and civil. Close coordination, cooperation, and information exchange will be maintained among these programs to avoid unnecessary duplication.

We have continued to maintain separate programs and to have separate policies governing these programs; but we have also developed a number of new interactive relationships which promote efficient coordination and management while protecting the integrity of NASA programs. We have just finalized a renegotiated shuttle pricing agreement with the Department of Defense. This new agreement will provide NASA with increased reimbursements of approximately $1 billion more in the next 5 years than the Agency would have received under the previous policy agreed to in 1977. This revised policy will raise the fiscal years 1986–88 shuttle launch cost to DOD by almost 150 percent, in fiscal year 1975 dollars, above the previously set launch price.

I would be remiss, Mr. Chairman, if I did not conclude this portion of my testimony by talking about the future. The President's space policy recognizes the importance of developing new concepts which provide a strong vision of the future, not only for our space program, but for the Nation as a whole. In his space policy, the President requires NASA to "continue to explore the requirements, operational concepts, and technology associated with permanent space facilities." The space shuttle makes it easier to establish larger permanent facilities in space. NASA's proposed fiscal year 1984 budget includes modest funding for definition and planning efforts which will allow us to understand, in greater detail, how such permanent facilities might be developed and maintained in Earth orbit. These studies will provide a basis for considering possible future proposals to establish a permanent manned station in Earth orbit.

[The prepared statement, plus answers to questions asked of Mr. Beggs, follows:]

Statement of

James M. Beggs
Administrator

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Committee:

It is a pleasure for me to appear before this distinguished Committee to present President Reagan's budget request for NASA for Fiscal Year 1984. The total request is $7.1 billion, of which $5.7 billion is for Research and Development, $150 million for Construction of Facilities, and $1.25 billion for Research and Program Management. A chart summarizing NASA's FY 1984 request is appended to this statement.

I am particularly proud to be at NASA in 1983 to celebrate its 25th Anniversary. During the 25 years since the United States entered the Space Age, our space program has grown from the 14 kg Explorer, launched in January 1958, to a truly reusable Space Transportation System.

With your permission, Mr. Chairman, I would like to spend a few minutes discussing some of the achievements of the past year -- achievements which have been very significant, indeed, and which would not have been possible without the strong and continued support of the Congress. In 1982, the Space Shuttle Orbiter Columbia made three successful orbital flights and, during each flight, significant progress was made in understanding the operational features of the Shuttle system. This initial phase of the STS flight program culminated with the first operational flight in November 1982, during which two commercial communications satellites were launched. There is no doubt in my mind, Mr. Chairman, that the investment this Nation has made in the Space Shuttle will pay off handsomely. We now know enough about the system so that I can make this statement with great confidence.

As you know, a new earth observation satellite, Landsat 4, was placed in earth orbit in July 1982, and its operations have been spectacularly successful. The satellite's new thematic mapper has provided informa-

tion of a quality exceeding the original specifications; it is providing valuable information for the geophysical sciences as well as excellent data for mapping and earth resources assessment. Additionally, our earth orbiting scientific satellites and other spacecraft in the solar system have continued to operate and to return extremely valuable scientific information.

In aeronautics, the Department of Defense has recognized the importance of NASA's technical contributions by considering NASA's tilt-rotor aircraft concept as a prime contender for the new joint service JVX vertical take-off and landing aircraft program. The XV-15 experimental aircraft, jointly developed by the Army and NASA, served as the proof-of-concept vehicle which made this recognition possible. Two large new aeronautical facilities are nearing completion, the National Transonic Facility at Langley Research Center and the new 80x120 foot addition to the 40x80 foot Subsonic Wind Tunnel at Ames Research Center. The completion of operational test and checkout of the new 80x120 foot leg has recently suffered a set-back because of an accident during testing. The facility is expected to be operational in about two years. NASA hopes to repair the facility and return it to operation as soon as possible to minimize delays to a number of priority NASA, DOD, and industry testing programs.

This is just a brief overview of some of the technical achievements of 1982--the list is really much longer. I will talk in more detail about some of the things that have been accomplished later on.

I would now like to turn to another achievement, a renewed commitment to the American space program from the highest levels of this Administration. On July 4, 1982, President Reagan issued a policy statement which outlines basic U.S. goals for activities in space. These goals are:

- to strengthen the security of the United States;
- to maintain United States space leadership;
- to obtain economical and scientific benefits through the exploitation of space;
- to expand United States private sector investment and involvement in civil space and space related activities;
- to promote international cooperative activities in the national interest; and, finally,

o to cooperate with other nations in maintaining freedom of space for activities which enhance the security and welfare of mankind.

The NASA budget request for FY 1984, which I am addressing today, is designed to achieve the objectives outlined in President Reagan's space policy--especially the maintenance of United States leadership in space. This is really the important word--leadership--and this Committee may rest assured that the Administration is strongly committed to what that word represents.

The key to leadership in space is to have efficient and effective ways of getting there. The President's space policy strongly supports the Space Shuttle program, and calls the Shuttle "the primary space launch system for both United States national security and civil government missions."

NASA's proposed FY 1984 budget fully supports a four-orbiter fleet, with enough structural and subsystem spares to make certain that the fleet is able to survive serious delays or accidents. Our proposal will also reduce the lead time for expansion or replacement of the four-orbiter fleet, if and when operational demands require. Our plans make it possible to meet the commitment to launch the payloads which we, and those depending upon us, have planned for at least the remainder of this decade. NASA's first priority, Mr. Chairman, remains: to make the Space Shuttle System fully operational as rapidly as possible. Additionally, we will continue to explore new ways of employing the full capability of the Shuttle. The proposed FY 1984 request continues funding of activities leading to a Shuttle mission to recover and repair on orbit the partially defunct Solar Maximum Mission (SMM) spacecraft in 1984. This will provide more useful life for the important SMM objectives and demonstrate the Shuttle's ability to perform such operations. Later on this year, we are scheduled to fly the first Spacelab mission which is an important demonstration of the new capabilities represented by the Space Shuttle. The Spacelab, developed and contributed by the European Space Agency, represents an important international activity consistent with the President's space policy.

Another international contribution to the Space Shuttle Program is the Remote Manipulator System (RMS) which was provided by the Government of Canada. The RMS successfully completed testing last year and in November was declared ready for operational use aboard future Shuttle flights.

NASA policy has recently been revised to expand opportunities for sponsors of Shuttle payloads to nominate payload specialists to fly with them. President Reagan invited a Brazilian payload specialist to fly aboard the Shuttle, and during his recent discussions with the Prime Minister of Japan, he extended a similar offer which was accepted. Australia and Canada have also accepted invitations for payload specialist nominations.

The second United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE '82), held in Vienna last August, helped to promote greater international awareness of the practical benefits of the applications of space science and technology.

In my testimony before this Committee last year, I said that the Space Telescope will be the most important scientific instrument we have ever flown. I continue to believe this is true, and NASA's FY 1984 budget request provides priority support to this very important development effort.

As might be expected in a program of this complexity, we are continuing to experience technical problems, particularly in the Optical Telescope Assembly development activities, which will most likely impact the scheduled launch and runout cost of the Space Telescope. We are currently reviewing a range of alternatives for rephasing the work to minimize the cost and schedule impact. As soon as our evaluation is complete, we will inform the Committee of our proposed actions.

Excellent progress is being made in other areas related to the Space Telescope. In a few months, we will open the doors of the new Space Telescope Science Institute which has been established at the Johns Hopkins University. Software and procedures for carrying out scientific investigations with this very complex space observatory are on schedule. The Space Telescope will open a new era of scientific opportunity and permit the U.S. to retain world leadership in astronomy.

Another measure of leadership in space is the continuing enterprise of planetary exploration. We have included in the proposed FY 1984 budget the initiation of a new program to map the surface of the planet Venus using radar imaging techniques. Within our overall strategy for planetary exploration, this initiative -- the Venus Radar Mapper (VRM), estimated to

cost in the $350 million range -- replaces, at a much lower cost, the Venus Orbiting Imaging Radar (VOIR) mission authorized by the Congress to begin in FY 1982. The VRM mission will help us understand why our sister planet, Venus, which is so much like the earth in size and physical composition, yet so different in other respects, has followed such a different evolutionary history. We will search for detailed properties in common with the earth, such as volcanic activity and continental drift. Aside from their intrinsic scientific value, observations provided by the VRM will help us to understand more clearly the history, nature, and most importantly, the future of our own planet.

The Advanced Communications Technology Satellite (ACTS) project, another new initiative proposed in the FY 1984 budget, calls for development and flight testing of the high-risk technology needed to ensure continued United States preeminence in the field of satellite communications. The decision to propose the ACTS program is a result of extensive consultation with communication carriers, satellite system suppliers, and strong support from the Congress. The ACTS program will involve a novel procurement approach, including a cost/risk sharing arrangement with industry which will provide significant cost savings to the government.

Another goal of the President's space policy is to expand private sector investment and involvement in space activities. NASA has received proposals from the private sector to fund and/or operate launch vehicles. We are reviewing these proposals very carefully to determine costs and benefits, launch and tracking requirements, safety and security, as well as international considerations.

In addition to the President's space policy which I have already discussed, the Administration has developed a new policy statement governing the needs for and management of Federally funded research and development work in aeronautics. In November 1982, the President's Office of Science and Technology Policy released a document entitled, "Aeronautical Research and Technology Policy." The aeronautics program included in NASA's FY 1984 budget request reflects many recommenda-

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tions contained in this important policy statement. The most important facet of the Administration's new aeronautics policy is the recognition that a strong aeronautical industry is absolutely essential for both the National security and the health of our economy. Furthermore, this policy recognizes explicitly the important role the Federal Government, through NASA, plays in providing the basic technology which will assist the United States in maintaining and enhancing the leading position in aviation which we now enjoy. In concert with this policy, we are submitting an FY 1984 budget request which continues to emphasize a strong aeronautical research and technology program, including a strengthened fundamental research program which will continue to provide the technical base upon which future aircraft designs can be based.

. The centerpiece of our proposed aeronautics program for FY 1984 is the new Numerical Aerodynamic Simulation (NAS) activity, which will be developed over the course of the next few years. The NAS capability will include a large computer system which will make it possible to perform most of the calculations required to design a new aircraft with sufficient accuracy and reliability to significantly reduce the long and expensive process of wind tunnel and flight testing now necessary. There is every reason to believe that the computer technology to achieve this objective can be developed in the next few years, and there is no question that the capability the NAS represents will make it possible to design new airplanes much more effectively. The investment made in NAS will provide incentives for various elements of the computer industry to produce machines which will be able to take advantage of major commercial applications. Developments of this kind will enhance the competitive posture of the United States in this important international market.

The FY 1984 budget proposed by the Administration also contains a number of items which are very important to the future of NASA's health as an institution. It is clear that the achievements I have outlined earlier in my testimony would not have been possible without a strong NASA institution. In the FY 1984 budget before you, there is a substantial increase in

funding for Construction of Facilities--$150 million as compared to approximately $100 million in FY 1983. We are also proposing the maintenance of the same number of civil service positions in FY 1984 as we have in FY 1983. The maintenance of our civil service strength is particularly significant because this manpower level will afford an opportunity for NASA to hire some of the best recent graduates of the foremost science and engineering schools in the Nation. We plan to take aggressive steps to bring in the best people we can find in order to strengthen NASA's institution for the long term.

In the past year, Mr. Chairman, concern has been expressed in the press and in the Congress about the appropriate relationship between NASA and those elements of the National security establishment with responsibility for space operations. I would like to take this opportunity to state categorically that this Administration is strongly committed to separate space programs, one dealing with civil sector operations and the other with those related to the National security. The President's space policy is very clear on this point, stating that, "The United States space program will be comprised of two separate, distinct, and strongly interacting programs--National security and civil. Close coordination, cooperation, and information exchange will be maintained among these programs to avoid unnecessary duplication." We have continued to maintain separate programs and to have separate policies governing these programs; but we have also developed a number of new interactive relationships which promote efficient coordination and management while protecting the integrity of NASA programs. We have just finalized a renegotiated Shuttle pricing agreement with the Department of Defense. This new agreement will provide NASA with increased reimbursements of approximately $1 billion more in the next five years than the Agency would have received under the previous policy agreed to in 1977. This revised policy will raise the Shuttle launch cost to DOD by almost 150 percent, in FY 1975 dollars, above the previously set launch price. We also have several Memoranda of Understanding with the Department of Defense which deal with various aspects of programs in order to avoid the

unnecessary duplication which the President mentions in his space policy.

I would be remiss, Mr. Chairman, if I did not conclude this portion of my testimony by talking about the future. The President's space policy recognizes the importance of developing new concepts which provide a strong vision of the future, not only for our space program, but for the Nation as a whole. In his space policy, the President requires NASA to "continue to explore the requirements, operational concepts, and technology associated with permanent space facilities." The Space Shuttle makes it easier to establish larger permanent facilities in space. NASA's proposed FY 1984 budget includes modest funding for definition and planning efforts which will allow us to understand, in greater detail, how such permanent facilities might be developed and maintained in earth orbit. These studies will provide a basis for considering possible future proposals to establish a permanent manned station in earth orbit.

I should stress that we are not now proposing to develop such a space station, but we believe that it is important to understand the uses to which such a capability could be put. We have every reason to believe, Mr. Chairman, that the Soviet Union has learned a good deal about manned operations in space from their experiences with Salyut 6 and Salyut 7. There is also evidence that the Soviets are planning more extensive activities in earth orbit, and we must understand potential benefits of such operations. It is important for the United States to take the necessary steps now to achieve these objectives.

Mr. Chairman, having discussed some of the important highlights, I would now like to proceed with a more detailed discussion of NASA's proposed FY 1984 program.

SPACE TRANSPORTATION

For FY 1984, the Space Transportation request is $3.498 billion. This includes $1.927 billion for Space Transportation Capability Development and $1.571 billion for Space Transportation Operations.

Since the budget hearings of last year the Space Transportation System has continued to mature. The Space Shuttle Orbiter Columbia made three flights in 1982, completing the Orbital Flight Test Program and initiating the transition into a fully operational system. STS-3 carried the first space science pallet of instruments and demonstrated the practical use of the Remote Manipulator System. STS-4 carried the first DOD payload; and STS-5, the first operational flight, demonstrated a number of "firsts." It was the first time the Shuttle's main engines were run above their rated power level (100 percent) during ascent; the first four man crew; and the first launch of commercial payloads, Telesat-E and SBS-C. STS-5 also carried a getaway canister, four student experiments and a joint endeavor experiment with McDonnell Douglas Corporation, to investigate the commerical potential of separating biological materials in space using a continous flow electrophoresis device. The success of the STS-5 contributed immensely to our image of having an operational system and demonstrated our ability to deliver commercial payloads.

We had planned to launch STS-6, the first flight of our second orbiter, Challenger, later this month. We have completed a first flight readiness firing on the Challenger main propulsion system in December, and found higher concentrations of gaseous hydrogen in the aft fuselage than we found on the flight readiness firing of the Comumbia. We repeated the Challenger flight readiness firing on January 25 with extensive instrumentation. This test confirmed, and we have now located, an elusive internal hydrogen leak. The tests also validated very low levels of oxygen in the aft fuselage. The leak was found on engine number one and this engine is being replaced with a flight spare engine. We should be able to proceed with STS-6 in March and to minimize our delay for subsequent flights. Additionally, we are developing operational tests and procedures to insure that future flights will not be subject to this type of delay.

The Space Transportation Capability Development Program provides for the National fleet of Space Shuttle orbiters, including main engines, and provides for the launch site and mission operations control requirements, initial spares, production tooling and related

activities to meet the needs of NASA, the DOD, and other domestic and international users of space. In addition, this program includes upper stages, Spacelab and advanced programs requirements. In 1983, the third orbiter OV-103, will be delivered for the first operational flight in early 1984. The FY 1984 budget will also allow for completion of the final assembly and integrated testing of OV-104, leading to a delivery at the end of 1984, and the acquisition or orbiter structural spares to support the existing orbiter fleet.

The FY 1984 budget will extend the Shuttle processing and launch capability with the continuing preparations for activating the second launch pad, initial construction funds for the third mobile launcher platform, and modifications to Pads-A and-B to make them Centaur-compatible.

In the upper stages programs, funds are requested to continue the development of Centaur-G, in cooperation with DOD, and Centaur-G prime to support the Galileo and ISPM launches in 1986. We also plan to use the Centaur-G to launch the Venus Radar Mapper in 1988. The budget allows for completion of the IUS vehicles to support four planned TDRSS launches.

The first Spacelab flight is scheduled for 1983. FY 1984 funds will support post-flight data analysis, and integration and checkout for the second Spacelab verification flight scheduled for FY 1985. Funding is also provided for payload support to the Spacelab 2 and Spacelab 3 missions, Galileo, ISPM, Space Telescope, and the SMM retrieval/repair mission.

In FY 1984, the major emphasis in Space Transportation advanced programs will be to define the system architecture and system elements for possible space operations over the next 20 years. Funding will provide for studies of earth-orbital platforms and facilities; orbital services such as satellite servicing; and advanced transportation concepts for reusable upper stages, teleoperated maneuvering vehicles and Shuttle derived Earth-to-orbit launch vehicle systems. FY 1984 funding will also provide for the initiation of hardware development of the Tethered Satellite System, a cooperative project with Italy. The Italians will develop the spacecraft and the U.S. will develop the deployment mechanisms and will be responsible for the program management and integration with the orbiter.

The Space Transportation Operations Program provides the standard operational support services for both of the primary U.S. government space launch systems -- the Space Shuttle and the expendable launch vehicles. The budget for FY 1984 will provide for production of Shuttle flight hardware (external tanks, solid rocket boosters, engine spares and orbiter spares); maintenance and operation of mission control and crew training systems; and the manpower necessary to support the launches planned for FY 1984. Ten sets of SRB hardware and 11 external tanks are scheduled for delivery in FY 1984.

In November, we awarded a base operations contract for NASA's Kennedy Space Center, to EG&G, Inc., aimed at strengthening support of our launch functions. Under this contract, there will be a clear assignment of responsibility and accountability and a reduction of management interfaces from fourteen to one. In late 1983, we expect to award a Shuttle processing contract which will further reduce the program management complexity and operational costs. The initial start up costs and projected manpower savings are reflected in the FY 1984 estimates. Later, we hope to issue a cargo processing contract to complete the consolidation of our efforts.

We have also taken steps to reduce production costs and increase launch capability. A significant milestone was reached last September when we took delivery of the first lightweight external tank five days ahead of a schedule set in 1980. Our goal was to reduce 6,000 pounds from the previous tank configuration and we actually achieved a 10,000 pound reduction. An additional improvement in payload capability of approximately 5,500 pounds is expected from the new filament wound case, for the solid rocket booster, which is planned for first use in late 1985. Programs are also underway to reduce recurring external tank and solid rocket booster production costs, include modification to the aft skirt structure, modifications in applying and removing tank TPS and development, of low cost solid rocket motor nozzle material.

In the Expendable Launch Vehicles program, the FY 1984 funding reflects the requirements to support the Delta launch vehicle's missions. We have recently

determined that the number of vehicles to be procured for non-NASA missions should be reduced commensurate with the revised reimbursable launch requirements. The Delta system is planned to be operational at least until 1986 to support the launch requirements of the National Oceanic and Atmospheric Administration.

SPACE STATION PLANNING ACTIVITIES

Last May, I established a Space Station Task Force to provide focus and direction to the Agency's planning activities for this potential major new initiative. The planning effort will be continued and expanded modestly in FY 1984 in order to generate the information, including costs and benefits, necessary for the Administration and Congress to make an informed decision on whether to proceed with some form of more permanent space facilities.

NASA's FY 1983 planning activity is focused upon understanding exactly what a space station could do, emphasizing the several areas of endeavor that utilize space: science, applications, technology development, National security, and commerce. We have deliberately steered away from design and configuration, directing our attention, and that of other interested parties, than to mission requirements and "architecture." Our goal is to have a thorough understanding of space station functions and the consequent attributes a station would require to carry out specific missions. Last summer, we sponsored eight small industry studies of potential space station missions. These are on schedule and will be completed shortly. Their results will be synthesized into potential time-phased mission sets which could be accomplished by a station in space. In addition, we have held discussions with our scientific and technical advisory committees, potential international partners and the Department of Defense to encourage them to review space station missions.

NASA's FY 1984 request includes $6 million within Space Transportation Advanced Programs which will be used primarily for space station systems engineering activities. An additional $6 million is included to augment on-going efforts in the FY 1984 Space Research and Technology program, principally to focus on key technology activities. In addition, $2 million is

requested in the Space Science and Applications program primarily for studies of science and applications payloads applicable to a space station. FY 1984 planning calls for identification of an "architecture" which could accommodate a preferred mission set, and further refinement of conceptual approaches.

SPACE SCIENCE AND APPLICATIONS

The past year's highlights for the Space Science and Applications program, in addition to the Landsat 4 launch, include the recent launch of the Infrared Astronomy Satellite (IRAS), and the outstanding early success of the Search and Rescue Satellite project.

Landsat 4 was launched in July, to provide more sophisticated and reliable data on earth resources. Landsat 4 carries a flight-proven Multispectral Scanner (MSS) and Thematic Mapper (TM) instruments for remote sensing. Data from these instruments have surpassed all expectations. The improved ground resolution and extended spectral range provided by the Thematic Mapper will enable users to recognize subtle differences in forest species, agricultural conditions, soil moisture and water turbidity that could not be detected in earlier MSS imaging. Approximately 4,000 TM scenes of the continental United States have already been acquired and archived during the first six months of Landsat 4 operations, and several research programs are now underway to evaluate in detail the quality and scientific utility of the Landsat 4 imagery.

IRAS, an extremely difficult and technologically challenging mission, developed in cooperation with the Netherlands and the United Kingdom, will execute the first comprehensive survey of the infrared sky, providing a new window to the universe. It is expected to revolutionize astronomy in the same way that the first ultraviolet and x-ray satellites did in the last two decades.

The Search and Rescue Satellite project, another significant international cooperative endeavor, began system checkout in September, and demonstrated its effectiveness almost immediately when a small aircraft which had crashed in a remote region in British Columbia was detected by the system. The injured pilot and two passengers were rescued. By mid-November, the new system was directly credited with saving ten lives in aircraft and marine accidents.

Our FY 1984 budget request of $1068.0 million for Space Science and Applications supports the two new

initiatives I mentioned earlier -- the Venus Radar Mapper and the Advanced Communications Technology Satellite -- and will enable us to pursue a vigorous program. The proposed budget supports the completion of the Landsat-D' spacecraft; it continues the Space Telescope development leading to a launch in 1985; it continues Galileo development leading to a single Shuttle/Centaur launch in 1986; and it continues International Solar Polar Mission (ISPM) instrument development support leading toward launch in 1986. It continues the hardware development of the Gamma Ray Observatory (GRO) leading toward a planned launch in 1988. It supports a 1984 launch for the Earth Radiation Budget Experiment (ERBE); technology development and analysis of flight experiments in Materials Processing; operation of the Pioneer Venus Orbiter, Pioneers 6 through 11, and Voyagers 1 and 2; support for the Infrared Telescope Facility and the Lunar Curatorial Facility; and continued development of experiments to understand the effects of weightlessness on man.

The Explorer development funding level is somewhat higher than in FY 1983 because this program offers important opportunities to address key space science questions in a highly cost effective manner. This level of FY 1984 funds will allow us to complete development of the Active Magnetospheric Particle Tracer Explorer (AMPTE), a project to determine how particles from the solar wind enter the Earth's magnetosphere; will support development activities for the Cosmic Background Explorer (COBE) satellite. The FY 1984 program will support initiation of the Extreme Ultraviolet Explorer (EUVE), which is expected to reveal new information on the structure and composition of interstellar media.

This proposed Space Science and Applications budget represents a commitment to maintain the momentum in scientific and technical excellence that has had such an important impact on the Nation and the world. It will continue the outstanding effort of the past, initiate new activities, and assure the preservation of the scientific research base that is critical to United States leadership in space.

TECHNOLOGY UTILIZATION

For FY 1984, we are requesting $4 million for Technology Utilization to continue the transfer of NASA-developed technology to U.S. industry, the public and other Government agencies. We have two primary program objectives: 1) to target applications engineering efforts to increase productivity in U.S. manufacturing industries, and 2) to improve the quality of

life and workforce through bioengineering and rehabilitation projects. We intend to enhance public sector technology applications projects in conjunction with other mission-oriented Federal agencies and industry with a view toward shifting budgetary responsibility for resultant projects to those entities.

AERONAUTICAL RESEARCH AND TECHNOLOGY

In FY 1984, a total of $300.3 million is requested for NASA's Research and Technology program, to provide the technology advances essential to the continued U.S. leadership in aeronautics. A strong base of technology is needed to develop future U.S. aircraft which will enhance our competitive position in the world aviation marketplace, and to provide continued superiority of the Nation's military aircraft. NASA's FY 1984 budget request continues to emphasize a strong fundamental research and technology base of activities as well as focused systems research activities, and constitutes a balanced effort in response to the Administration's recently enunciated aeronautics policy.

In FY 1984, emphasis in fluid and thermal physics will be applied to turbulent drag reduction, internal computational fluid dynamics, and high Reynolds number cryogenic testing to be provided by the National Transonic Facility at NASA'S Langley Research Center. This facility, which will become operational in June 1983, will provide the most advanced transonic speed test capability in the world. Using models of the world's most advanced aircraft, this facility will allow near exact simulation of flight conditions. Areas of emphasis in materials and structures will include ceramics, new composite materials, and transport crash dynamics. In controls and human factors, new research capabilities will be provided by the Man-Vehicle Systems Research Facility at the Ames Research Center and the Avionics Integration Research Laboratory at the Langley Research Center. The upgrading of capabilities in computer science and applications will continue to receive major emphasis, with expanded efforts directed toward technology for fault tolerant systems. In propulsion, emphasis will be placed on intermittent combustion engines, helicopter and turboprop transmissions, engine dynamics and stall recovery, and small radial turbomachinery. Rotorcraft research will stress noise and vibration reduction and the unsteady aerodynamics of rotors. Research will also be conducted to investigate guidance and control for all-weather rotorcraft operations, composite tilt rotor blades and technologies aimed at improving performance and flying qualities of the tilt rotor vehi-

cle class. Areas of emphasis in high-performance aircraft research will include supersonic cruise technology, hypersonic propulsion, structures, configuration aerodynamics, and propulsion/airframe integration. Also included will be flight evaluations of advanced concepts using special F-16 and F-111 aircraft to investigate new technologies for enhancement of fighter performance. The proof-of-concept flight research phase of the NASA/Defense Advanced Research Projects Agency (DARPA) X-29A forward swept wing vehicle will begin, and increased effort will be provided in the Turbine Engine Hot Section Technology program to study means for increasing engine performance and durability. In subsonic aircraft, research emphasis will be placed on commuter aircraft technology, icing and lightning research, natural laminar flow, and problem areas identified in coordination with the Federal Aviation Administration as critical to improved air safety and operations.

In FY 1984, program augmentations are planned in the important long-lead, high-risk technology areas: numerical aerodynamic simulation, large composite structures, and rotorcraft. The Numerical Aerodynamic Simulation initiative will significantly augment the Nation's program in computational fluid dynamics and other areas of computational physics. It will provide advanced capability for users nationwide for computational aerodynamics, computational chemistry, and other complex analytical problems. Advanced composite structures technology will address thick, load-critical primary structures representative of large aircraft wing-structure sections; curved panels to investigate fuselage design technology problems; and new generation materials for increased toughness and impact resistance. Technology for next-generation rotorcraft will pursue further understanding relative to two high-speed rotorcraft concepts -- the advanced tilt rotor technology and the DARPA X-wing utilizing NASA's Rotor Systems Research Aircraft.

SPACE RESEARCH AND TECHNOLOGY

NASA's FY 1984 Space Research and Technology request of $138 million will focus on providing advanced technology in support of NASA's role of maintaining the U.S. preeminence in space. This investment in research and technology is essential for improving operational capability, reliability, and affordability of existing and planned NASA missions, as well as providing the technology base and technology options for rapidly expanding military and commercial space interests.

The FY 1984 budget continues to emphasize a strong Research and Technology (R&T) base of activities in the discipline areas of fluid and thermal physics, chemical propulsion, materials and structures, computer science and electronics, space energy conversion, controls and human factors, and space data and communications. The computer science and space human factors disciplinary activities represent new elements in the R&T base that respond to important future systems needs, as well as to identifiable, high-leverage, technological advancements. In addition, activities in spacecraft, transportation, and platform systems research are designed to study the inter-relationships of discipline technology from an integrated systems point of view. These efforts are critical to the successful transition of technology from the laboratory to useful application. In FY 1984, a modest expansion to the base program in platform systems is planned to investigate technology options that could enhance capabilities and growth potential of permanent space facilities.

The Systems Technology effort in FY 1984 will focus on the following technology missions or experiments: launch of the long-duration exposure facility, the solar array flight experiment, solar cell calibration facility, tribology experiment, reflight of the feature identification and location experiment, launch of the ion auxiliary propulsion system, design activity on a space technology experiment platform, and a cryogenic fluid management facility.

ENERGY TECHNOLOGY

During the past year, NASA has continued to support the Department of Energy (DOE) and other agencies in energy research and technology development. Important progress was made by NASA's Lewis Research Center in advancing ceramic component technology for the automotive gas turbine, and in improving the life and performance of advanced phosphoric acid fuel cell systems.

In FY 1984, NASA will continue to support those energy programs which were initiated in prior years, and which the DOE or other sponsoring agencies desire NASA to continue. We intend to complete our previous commitments as efficiently as possible to ensure the integrity of the government investment made to date. For the future, it will be our policy to concentrate on energy programs which have objectives which are synergistic with NASA's aeronautics and space programs.

SPACE TRACKING AND DATA SYSTEMS

For the Space Tracking and Data Systems program in FY 1984, NASA is requesting a total of $700.2 million, which includes $294.7 million for acquisition of service via the Tracking and Data Relay Satellite System (TDRSS) as well as support of TDRSS related elements. This request provides for the continuation of the vital tracking, command telemetry and data acquisition support to meet the requirements for all NASA flight programs.

The Spaceflight Tracking and Data Network (STDN) and the Deep Space Network (DSN) will continue to provide support to both near-Earth orbiting satellites, including the Space Shuttle operational flights and deep space probes. In FY 1984, numerous applications and scientific Earth-orbiting and planetary missions will be supported.

The launch of the first and second TDRS spacecraft are scheduled to be launched in 1983. The TDRSS is planned for full operational capability in 1984. The TDRSS service contract has been restructured to convert the TDRSS from a shared system providing both support of government space missions and commercial communications satellite services, to a system dedicated to providing support to space missions. The FY 1984 budget request reflects the initial full year funding requirements for TDRSS service and the phaseout of most of the STDN ground stations after TDRSS is operational. Ground stations planned to be closed during FY 1984 are Guam, Hawaii, Ascension, Santiago, Dakar, and Botswana, with termination of STS VHF voice communications from Yarragadee, Australia, and the AF Indian Ocean site. The remaining facilities will then be consolidated with the DSN stations under management of the Jet Propulsion Laboratory (JPL), or dedicated to support of launch and landing operations. The consolidation will result in a single ground network to support geosynchronous, highly elliptical, and all planetary missions.

CONSTRUCTION OF FACILITIES

The Construction of Facilities (CoF) request for FY 1984 totals $150.5 million. Slightly over one-third of the request, $53.3 million, is required for Space Shuttle and payload facilities. The request includes $24 million for aeronautics and space technology activities and $58 million for repair, rehabilitation and modification, minor construction, and facility planning and design. The FY 1984 CoF request strikes an appropriate balance between NASA's need to meet increasing Shuttle flight rates, improve Shuttle manufacturing and processing efficiencies, provide enhance-

ments of existing facilities to afford improved research and testing capabilities, and to repair and preserve our present physical plant.

The Space Shuttle CoF projects are in direct support of achieving a 24-flight-per-year capability. Based on the experience to date, it is NASA's current assessment that two Mobile Launcher Platforms (MLP'S) can support up to 16 flights per year. Thus, the project for modifying a third mobile launcher platform for Shuttle use, at a cost of $27.3 million, is required to reach 24 flights per year from NASA's Kennedy Space Center (KSC). The other large Shuttle- related projects reflected in the request are the construction of a Cargo Hazardous Processing Facility at KSC ($9 million), and some additional modifications to the External Tank (ET) manufacturing facilities ($11.7 million) at the Michoud Assembly Facility in New Orleans.

In the non-Space Shuttle area, our FY 1984 construction request is similar to those of recent years, providing for prudent investments necessary to preserve and improve existing research facility capabilities. An example is the Small Engine Component Testing Facility proposed for construction at NASA's Lewis Research Center. Modification of test cells in the Engine Research Building at LeRC are necessary in order that a critical need for testing and development of small turbine engines can be met. This project is typical of our continuing emphasis on modifying and improving existing facilities to meet new research and technology needs of the country.

Of equal importance is the $58 million requested in FY 1984 for minor facility projects. These are critical to the repair and preservation of an aging physical plant and to ensure that NASA's facilities are capable of meeting today's technology needs.

RESEARCH AND PROGRAM MANAGEMENT

The Research and Program Management request for FY 1984 is $1,247.5 million. About three-fourths of this required for civil service salaries and related costs. About two percent is for travel which is vital to the management of our R&D programs. The belance is for facility support and related goods and services necessary for the operation of NASA Centers.

The FY 1984 plan provides for a NASA civil service workforce at approximately the present level, the first time in several years that we have not been planning to accomplish some kind of personnel reduction in the

current and budget years. Staffing stability of this kind is important for an R&D organization such as NASA. It allows us the opportunity to hire new scientists and engineers to assure the vitality of our technical workforce. It will also enable us to solve minor skill-mix problems that arose in previous years when we were faced with accommodating ceiling reductions. In FY 1983 and 1984 we will be able to plan our hiring in a more effective manner. Although I believe that NASA's workforce is one of the strongest and most creative in the world, we need the influx of people with new viewpoints, different skills, and knowledge of the latest technology in many diverse areas to maintain and improve this outstanding national asset.

The requested R&PM funds will provide for essentially the same level of operations in FY 1984 as planned in FY 1983, considering estimated price levels which are expected to rise at a significantly slower rate than we have experienced in the past years.

As you are aware, the President is very interested in increasing the productivity and improving the quality of all governmental activities. In order to provide leadership in this area and to provide coordination for the many productivity-related activities in both Headquarters and at the Centers, I have formed a steering committee composed of the top management officials of the Agency. The steering Committee is focusing on our overall goals of (1) maintaining NASA as a leader in the development and application of advanced technology and management practices which contribute to significant increases in both Agency and National productivity and quality; (2) identifying areas where NASA practice is behind the state-of-the-art in productivity and quality and to initiate actions to effect improvement; and (3) enhancing awareness among management, the workforce and our contractors of the need to achieve increases in our productivity. We are already moving on some specific productivity initiatives in reducing paperwork throughout the Agency, in introducing common and shared administrative automatic data processing systems and coordinating an Agency-wide plan for information through office automation.

Finally, I am pleased to point out that, even with the significant civil service personnel reductions in FY 1982, we were able to improve the ratio of minority and female professional employees in the NASA workforce. Last year the ratio of minority professionals in the workforce rose from 8.4 percent to 8.7 percent, and for females in professional position from 11.6 percent to 12.2 percent. Consequently, minority and female professionals now make-up 19 percent of

NASA's professional workforce and 28.7 percent of the total workforce.

CONCLUSION

In conclusion, Mr. Chairman, I believe that NASA's FY 1984 budget request represents a well-balanced program which fully funds the Space Transportation efforts, provides for continuing programs in Science, Applications, and Aeronautics, and reflects several important new Research and Development initiatives. This request also reflects, significantly, an augmented Construction of Facilities program, and a stabilized NASA civil service workforce level. I trust that the Committee will recognize this as a balanced and healthy proposal, which reflects the Administration's commitment to a vital U.S. civilian space program, and that the Committee will fully support NASA's proposed FY 1984 budget.

19-605 O—83——3

Questions submitted by Chairman Volkmer during the February 3,1983, hearing.

QUESTION A-1:

a. Does the NASA FY 1984 budget request fully support the goal outlined in the Space Act of maintaining this Nation's leadership in aeronautical and space activities?

b. What role did the Senior Interagency Group (SIG) play in fiscal year 1984 budget negotiations?

ANSWER A-1:

a. Yes, in my judgment the FY 1984 budget will provide for a program consistent with the role of the United States as a leader in the most important areas of aeronautical and space science and technology.

b. The SIG (Space) had no direct role in the FY 1984 budget negotiations. The SIG did provide advice on various options for Shuttle production rates and the production of structural spares.

QUESTION A-2:

Could you list the new start candidates which NASA requested from OMB in order of priority? Please elaborate on the rationale for establishing the priority among these candidate new starts.

ANSWER A-2:

The new start activities included in the NASA recommendation to OMB in September were as follows in priority order:

Numerical Aerodynamic Simulation

Fifth Orbiter

Advanced Communications Technology

Venus Radar Mapper

Upper Atmosphere Research Satellite

Tethered Satellite

The recommendation to the OMB also included a Space Station Definition effort at a high priority level.

The priorities are developed through a series of judgments based on many factors including the following: The national objectives in aeronautics and

space; the technical readiness and confidence with which the project can be undertaken; the relationship of the effort to approved program activities; the estimated cost of proposed project; and the alternatives in terms of other proposed initiatives or augmentation of currently approved programs.

The FY 1984 budget recommendation to Congress includes the Numerical Aerodynamic Simulation project, the Advanced Communication Technology Satellite, the Advanced Composite Structure Technology effort, the Venus Radar Mapper and the Tethered Satellite. The Upper Atmosphere Research Satellite spacecraft development was deferred but work on the instruments is continued. A fifth orbiter is not included in the program but structural spares and components to increase confidence in operation of the four-orbiter fleet are included. Provision for Space Station study and technology effort is included but the proposed system contractor definition activities have not been included in the level originally recommended.

QUESTION A-3:

The combination of budget constraint and increased Shuttle funding requirements have created a shift in the balance of funding within the NASA budget. Shuttle funding has increased from 53.7 percent of Research and Development (R&D) funds in fiscal year 1978 to 63.6 percent in fiscal year 1983. This translates to a shift of more than $500 million in FY 1983 dollars.

a. Are you concerned about this trend?

b. Do you see this trend continuing?

c. What can be done to reserve this shift?

ANSWER A-3:

Yes, we are concerned with maintaining an appropriate balance in the budget among the major areas of activity including space transportation, science and applications, aeronautics and longer range technology. It is reasonable to expect that funding ratios among program elements will vary in the budget each year depending on development status of individual projects and on other considerations. Over the past few years, the completion of Shuttle development and establishment of an operational capability have held high priority in the budget. Funding requirements for Space Transportation reached a peak in FY 1983. At the same time, effort in other program areas has been funded at a productive level. The FY 1984 budget recommendation reflects a reduction in both the absolute amount and the percentage of the budget applied to space

transportation and an increase in the other program areas.

QUESTION A-4:

Could you elaborate on the "hydrogen leak" problem which has delayed the launch of Challenger?

ANSWER A-4:

The "hydrogen leak" problem referred to during the recent congressional testimony, occurred during the static firing of Challenger at KSC last month, and has been identified with one specific engine. Inspection of the flight engines has revealed a 3/4 inch crack in the Main Combustion Chamber (MCC) outlet manifold of engine 2011. Since finding the crack, NASA and contractor technicians have conducted several tests at KSC and Rocketdyne to measure the leak rate. Data from these tests have correlated very well with the actual quantity of H_2 concentration detected in the Challenger aft compartment during the subject static firing at KSC.

The precise cause and/or sequence of events leading up to the crack in the fuel manifold on SSME number 2011 is not completely clear at this writing; and, a multifaceted failure investigation is continuing. The specific MCC manifold in question has been reworked by the contractor during the manufacturing process. The rework was a deliberate decision to save a high cost part from being scrapped because of a manufacturing error. It is strongly suspected that the rework process contributed to the development of a crack under engine test conditions. Because the rework was unique to this manifold, it is believe that this problem is not generic to the other engines.

Since the leak was isolated to a single engine (2011), it has been removed and will be replaced with another flight engine. With this action, the problem is no longer considered a constraint to flight STS-6.

QUESTION A-5:

We understand that the Shuttle launch delay has created a conflict between commercial customers, the first Spacelab flight, and a DOD flight.

a. Could you elaborate on this conflict?

b. We understand that the DOD flight is not truly critical from a schedule standpoint. Is this accurate?

c. Do you expect DOD to insist on receiving priority?

ANSWER A-5:

a. There is no conflict at this time between commercial customers, the first Spacelab flight, and the DOD flight. There will, of course, be a delay of STS-7 and STS-8 from the original schedule that had STS-6 being launched January 20, 1983. We have discussed the impact of this slip with all customers concerned. If we are able to launch STS-6 early in March, we believe that the delay to STS-7 and STS-8 from their previous schedule based on a STS-6 launch on January 20, 1983, will not be significant and is acceptable to all customers.

As is prudent, we have worked contingencies of greater delays than now anticipated in order to work up schedules that might be acceptable to all customers involved. Some of these contingencies did consider later Spacelab flights in assessing the impact on science data, etc.

b. This is not accurate. DOD can accept a schedule adjustment of a week or so, but a much longer delay would be a serious problem.

c. DOD has supported our contingency planning and has been willing to adjust, if necessary, as noted previously.

QUESTION A-6:

Last year NASA announced a schedule slip and a cost increase on the Space Telescope program. In the past week we have again been informed about additional schedule delays and cost increases.

a. Could you elaborate on these cost and schedule problems?

b. Are you facing technical management problems?

c. Do you understand the problems as well as the solution?

d. What is being done to bring increased management focus on these problems?

ANSWER A-6:

a. The Space Telescope was recognized from the outset as a very challenging technical development primarily because of the extremely precise pointing requirements involving state-of-the-art advances in the design, development, and test of the control and stabilization systems. In addition, manufacturing of the 3-meter mirror, flight software development,

instrument electronics, and tight structural specifications were identified as potential risk areas. The Space Telescope funding estimate included significant contingency in anticipation of potential development problems. Two years ago, we determined that progress on the fine guidance sensor and associated system in the Optical Telescope Assembly was behind plan and the Support System Module design was more complex than originally anticipated. A special review team assessed the status of the program and concluded that the launch date should be changed from the fourth quarter of 1983 to the first half of 1985. The development estimate was increased by about $150 million including reserves for potential technical problems and the recommended schedule adjustment. The details of these adjustments were described in the Space Telescope Program Status Report dated January 31, 1981.

The current status is that development of the fine guidance sensor continues to pace the program and we are continuing to encounter difficulties with the functioning of the instrument latches. In addition, we have identified the need for additional special test and checkout support equipment. The schedule and cost impact are under special review at this time.

b. We are facing both technical and management problems and we will undertake a strong independent effort to rebaseline the program consistent with the technical risks we identify and to realign program management in NASA and at the contractors to focus greater attention on these areas.

c. As stated earlier a detailed assessment of current problems is underway at this time. The NASA Administrator and the NASA Chief Engineer are scheduled to review the current status of the Space Telescope development activities with the responsible NASA Centers and the two associate contractors, Perkin-Elmer Corporation and Lockheed Missiles and Space Company.

d. The Executive Vice President has now taken charge of the Space Telescope project within Perkin-Elmer; therefore, it is NASA's belief that the Space Telescope development will receive a much higher priority within their internal management structure. Based on the results of our current assessment, additional management changes may also be implemented.

QUESTION A-7:

a. Since the authorization hearings last year, has there been any change in the schedule commitments for delivery of the production orbiters?

National Aeronautics and Space Administration

FY 1984 BUDGET REQUEST
(dollars in millions)

	FY 1982	FY 1983	FY 1984
Space Transportation Capability Development	2623.4	2144.1	1927.4
Space Transportation Operations	466.5	1453.7	1570.6
Space Transportation	3089.9	3597.8	3498.0
Physics and Astronomy	322.5	441.0	514.6
Life Sciences	39.5	55.7	59.0
Planetary Exploration	210.0	186.4	205.4
Space Applications	324.2	351.0	289.0
Space Science and Applications	896.2	1034.1	1068.0
Technology Utilization	8.0	9.0	4.0
Aeronautical Research and Technology	264.8	280.0	300.3
Space Research and Technology	111.0	123.0	138.0
Space Tracking and Data Acquisition	402.1	498.9	700.2
Research and Development	4772.0	5542.8	5708.5
Construction of Facilities	113.7	97.5	150.5
Research and Program Management	1134.4	1199.1	1247.5
TOTAL	6020.1	6839.4	7106.5
Outlays	6035.4	6721.5	6981.1

b. What are the delivery schedules envisioned by the budget request?

c. Do the currently envisioned production orbiter delivery schedules satisfy Department of Defense requirements?

ANSWER A-7:

a. There have been no changes in the delivery dates of the remaining production orbiters since last year's hearing. The planned modification period to bring OV-102 to its full operational capability has been delayed to FY 1985. However, pending the results from the experience of operating two differently configured orbiters, we may move this modification forward into FY 1984. The schedule for completing OV-104 and performing the modifications to OV-102 would be reviewed at that time to determine whether any schedule adjustments are necessary.

b. Delivery dates consistent with the FY 1984 budget are as follows:

OV-103 - September 1983
OV-104 - December 1984

c. Yes, the current production delivery schedule supports Air Force launch requirements for both Cape Kennedy and Vandenberg operations. VAFB operations are expected to be initiated in mid-1985, with the initial launch schedule for late 1985.

QUESTION A-8:

a. What is the status of NASA plans for a fifth orbiter?

b. Has NASA analyzed the impact on the production costs of additional delays in this decision?

c. In the budget submission to OMB, how much did NASA request for the fifth orbiter?

d. How much funding would be required in FY 1984 to initiate production of the fifth orbiter?

ANSWER A-8:

There are no funds in the FY 1984 budget for procurement of a fifth orbiter. Over the past year NASA has studied the need for additional orbiters, with emphasis on the requirement for a fifth orbiter. The results have shown that four orbiters can more than meet mission manifest requirements through the end of the decade.

However a theme emerging from the studies was the need for a measure of assurance to accommodate downtimes caused by unscheduled maintenance, systems upgrade, and accidents causing extensive damage or loss of an orbiter. The FY 1984 budget included, of a plan total of $420 million, $100 million for the procurement of orbiter structural spares. These spares will significantly reduce orbiter downtime in the event of the need to replace damaged structural components. They can also be used to reduce the lead time to manufacture a fifth orbiter if national needs so dictate. This approach also protects our production capability in the major structural subcontractor areas.

b. Prior to the authorization of the structural spares, internal analysis predicted the cost to acquire OV-105 would increase by $150-200 million if the decision to proceed was delayed from FY 1984 to FY 1985.

The authorization of the structural spares for the orbiter fleet will reduce the additional cost for the procurement of a fifth orbiter at a later date. While there will be some impact due to inflation, stretched out support costs and production gaps associated with the delay, the procurement of structural spares will significantly reduce the cost to procure a fifth orbiter. We are presently in the process of studying the effects of the spares procurement on the schedule and production costs if OV-105 were approved at some later date.

c. NASA requested $200 million in FY 1984 to initiate procurement of OV-105. Total costs were estimated to be $1.8 billion, based on a September 1988 delivery. This total cost estimate excludes those costs for an augmented production and launch rate capability in excess of 24 launches per year.

d. If the $100 million requested for orbiter structural spares was applied to the production of the fifth orbiter, an additional $100 million in FY 1984 would be required to initiate production of a fifth orbiter based on a late 1988 or early 1989 delivery.

QUESTION A-9:

In the legislative reports accompanying the fiscal year 1982 and 1983 authorization legislation, the Committee requested a joint NASA/Air Force review of requirements for additional orbiters. (The review was requested by August 1, 1982.)

a. How has NASA and the Air Force responded to this request?

ANSWER A-9:

a. As requested by Congress, NASA initiated a study of the requirements for additional orbiters. At the same time this study was being conducted, a review of space policy was initiated by the White House Office of Science and Technology. Under OSTP auspices, an interagency Space Policy Study Steering Group (including the DOD) was formed to develop issues and recommend attendant policy statements. The requirement for expansion of the orbiter fleet was an important part of that study.

Additionally, a Senior Interagency Group also examined the fifth orbiter requirement. These examinations focused on impacts of a loss or extended downtime of one of the currently authorized four orbiter fleet and on the likelihood of projections of future growth being realized beyond the capabilities of the our orbiter fleet.

The results of the studies have shown that four orbiters can meet the mission manifest requirements for at least the remainder of this decade. However, a theme emerging from the studies was the need for a measure of assurance to accommodate unscheduled maintenance, system upgrades, aborts, and accidents causing extensive damage or loss of an orbiter.

The proposed orbiter structural spares will provide the assurance necessary for the Nation to operate the four orbiter fleet in a robust manner. The FY 1984 budget includes $100 million of a planned total of $420 million for the procurement of orbiter structural spares. These structural and component spares will provide the necessary assurance that Shuttle operations will continue in the face of minor problems, modifications, or other periods of extended orbiter outages.

Another important benefit to procuring the structural spares is the protection of our orbiter production capability. Following delivery of the OV-104 hardware, many structural and component subcontractors would otherwise be closing down their orbiter lines; this action preserves major areas of production capability for an additional 1-2 years, depending on the element.

QUESTION A-10:

Could you elaborate on the most recent report of the Aerospace Safety Advisory Panel related to the Space

Shuttle? Are your aware of any unresolved safety issue concerning the Space Shuttle?

ANSWER A-10:

The Panel's most recent annual report was presented to the NASA Administrator on February 8, 1983, covering its activities for the calendar year 1982. The Panel reported upon various facets of the Space Shuttle program and on aircraft flight safety. With respect to the Shuttle they made the following recommendations:

- A formal program should be implemented to identify flight test objectives compatible with each new Shuttle mission so that the entire flight envelope will be defined in a timely manner.

- Extreme caution should be used when decreasing structural safety facets for weight reduction purposes until all pertinent data are explored; as a corollary, appropriate instrumentation packages should be carried unitl flight limits are determined.

- NASA should identify a single, responsible operational logistics group, properly staffed, to assess logistics methodology to be followed.

- During the operational period, the sustaining engineering should be the responsibility of the operational organization.

- Current and future changes in the Shuttle must have the same rigor of hardware/software certification as in the past. Such policy and standards should be established by an independent group, e.g., NASA's Chief Engineer, and should have the direct sponsorship of the NASA Administrator.

- Autoland of the orbiter should be tried at the earliest opportunity where there is a "repeat" pilot who has made a previous manual orbiter landinng.

- New turbomachinery for the main engine should be designed to achieve current mission life at the full power level.

- A gear redesign study should be initiated to achieve an adequate factor of safety with the maximum proposed Shuttle loads.

QUESTION A-11:

Has the Aerospace Safety Advisory Panel reviewed the safety issues related to use of a modified Centaur with the Space Shuttle?

ANSWER A-11:

The Panel during its 1982 activities briefly touched on the Centaur project for initial familiarization, and has plans to examine the Centaur project in much greater detail in 1983. Payloads such as the Centaur, which have propulsion and pyrotechnic elements or which extend beyond the payload bay door envelope during the mission, are of particular interest to the Panel. This activity will be a natural follow-on to Panel examination of the range of payload-to-orbiter interfaces having potential hazards. Arrangements are currently being made for the necessary fact-finding sessions at both NASA and contractor sites involved with the design, test, and technical management of the Centaur hardware and software.

QUESTION A-12:

Could you elaborate on the status of NASA plans for maintaining the Delta and Atlas-Centaur production lines? What efforts are underway to reduce the Delta and Atlas-Centaur costs to assure a competitive posture with regard to Ariane?

ANSWER A-12:

The Atlas-Centaur and Delta launch vehicles are produced for firm vehicle users. At present, we have sufficient vehicles on order to satisfy all customers desiring launches on these expendable vehicles.

NASA has recently placed a stop work order on Delta vehicle production to terminate the last six launches on the current contract to conform with known launch requirements. While production of the vehicle will end in 1983, the use of the Delta vehicle is now projected through the end of 1986 to accommodate the launch of NOAA's GOES-G and -H spacecraft.

Atlas-Centaur vehicles are also being produced in sufficient quantity to satisfy only firm customer requirements and its production termination date has not yet been established, but likely be in 1985. DOD use of the Atlas vehicle is planned through 1987. Eight launches are currently planned with the last launch scheduled for early 1987.

NASA planning calls for the utilization of the Space Shuttle and phaseout of the U. S. Government's use of these expendable launch vehicles upon the completion of these launch requirements. Price competitiveness with the Ariane is, accordingly, not a program objective for NASA's expendable launch vehicles.

QUESTION A-13:

a. What do you view as NASA's future role in civil space applications?

b. Would you support increased emphasis for space applications activities?

ANSWER A-13:

a. Major new applications are recognized from time to time from the capability that NASA's space activities in science and technology generate. We now have several; namely, communications, satellite meteorological observations, earth remote sensing, and materials processing. Continuing contact with practical applications has been a strong stimulus to further research, which serves both to extend our knowledge and to broaden the field of potential applications by providing a better foundation of science and technology. Until the next major application area appears, NASA will be pursuing a strong program of technology and basic science. This work is important in its own right, and the results will be applicable to improve practical performance. We will, of course, be working closely with the concerned Government agencies and private sector entities to ensure that the results can be swiftly put to use.

b. As major new possibilities for application are identified, increased emphasis on bringing them to practical fruition would certainly be expected. However, increased emphasis within NASA only is not sufficient. Our experience shows that the development of new applications capability works well only with the participation, both intellectual and financial, of those who have the capacity to put the new capability to work.

QUESTION A-14:

Other nations, notably France and Japan, have recognized the economic importance of satellite earth remote sensing and are developing their own satellite systems. Is the United States doing everything it can to ensure that the United States, who pioneered satellite remote sensing, continues to develop the applications for this important data?

ANSWER A-14:

France and Japan have indeed recognized the economic importance of the information available from earth remote sensing, and they are developing their own satellite systems within their customary government/

industry cooperation. Likewise, the United States recognizes this potential and is moving to ensure the widest possible exploitation of the capability with cooperation between the public and private sectors. A driving force in the U.S. actions is the conviction that the innovative, flexible, and entrepreneurial activities of the private sector are the fastest and best route to full realization of the capabilities of earth remote sensing. Thus, the Government is moving to transfer civil remote sensing to the private sector, while continuing to support the field by funding support activities in the underlying science and advanced technology areas.

QUESTION A-15:

How do you view the future for NASA's planetary program? Does the President's Science Advisor share this view?

ANSWER A-15:

The FY 1984 budget request includes initiation of the Venus Radar Mapper (VRM) mission as a part of the planetary program. This is an important next step in the planetary program as outlined by the Solar System Exploration Committee (SSEC). The future of the planetary program remains bright. The potential for the planetary exploration program in the future will depend upon the formulation of a coherent scientific program that embodies the positive attributes and efficiencies of approach which will hopefully decrease the cost of planetary missions. The task of formulating recommendations for future planetary missions lies with the Solar System Exploration Committee. We have every expectation that the final report of the SSEC will identify several potential new planetary missions for the future.

Dr. Keyworth has been very supportive of the need for undertaking the Venus Radar Mapper (VRM) mission. The FY 1984 planetary program budget request, which includes the VRM mission, is indicative of the Administration's view of the importance of planetary exploration.

QUESTION A-16:

What is the status of activities related to the "Global Habitability Initiative" proposed by NASA at UNISPACE 1982?

ANSWER A-16:

We are continuing to formulate the basic concept of a multidisciplinary scientific research activity focusing

on processes relating to the habitability of the earth. At present, three main activities within NASA are underway:

- A program plan is being developed to identify those areas to which NASA can make a significant contribution. This document will also act as a talking point in future discussions with both U.S. Government agencies and international organizations.

- Science working groups have been assembled to define, the scientific objectives and rationale for the program.

- Preliminary discussions have begun with some of the U.S. Government agencies (NOAA, DOI) to define areas of coordination and cooperation.

- Concept presentations are planned in the next few months, at national and international scientific and technical meetings.

QUESTION A-17:

What are NASA's plans with regard to developing an ocean observing satellite?

ANSWER A-17:

The objectives of NASA's oceanic processes activities is focused on evaluating the utility of spaceborne techniques for observing the oceans and applying these techniques in advancing the understanding of the fundamental behavior of the oceans. In order to minimize total program cost, we are concentrating on those satellite ocean sensors with the greatest near-term potential for contributing to the understanding of the fundamental behavior of the oceans. We are also looking at various flight concepts for the satellite ocean sensors.

NASA is currently studying a potential mission that has been designated the Ocean Topography Experiment (TOPEX) which would focus on the determination of the general circulation (or current structure) of the global oceans. Not only would an improved understanding of the oceanic circulation and the associated redistribution of heat help assess the influence of the oceans on atmospheric climate, but information on the global wind and wave field would be useful to operational users.

NASA is also studying the possibility of deploying a scatterometer on the Navy's Remote Ocean Sensing System (NROSS) as well as deploying a color scanner abroad the

NOAA series of operational meteorological spacecraft. The scatterometer, which would map the surface wind field, would contribute to the TOPEX objective, and at the same time satisfy Navy operational requirements; the color scanner, which would map cholorophyll concentration associated with phytoplankton, would contribute to the understanding of primary productivity in the oceans while at the same time satisfy NOAA operational requirements. Operationally, these two sensors would contribute to improved marine forecasting and fisheries management.

For data from other sensors, we are looking to non-NASA sources. For example, we are investigating the scientific uses of data from the Air Force's microwave radiometer (the SSMI) abroad the DMSP series of operational meteorological satellites, scheduled for launch in 1984; and from the Navy's altimeter abroad Geosat, also scheduled for launch in 1984. We are conducting preliminary discussions with: (1) the European Space Agency regarding having access to data from the synthetic aperture radar (SAR), scatterometer, and altimeter aboard their ERS-1 spacecraft, which is scheduled for launch in 1988; (2) the Canadians regarding the SAR aboard their Radarsat, scheduled for launch in 1990; and (3) the Japanese regarding data from their MOS-1, scheduled for launch in 1985. Moreover, we are exploring options for possible deployment of ocean sensors aboard ERS-2 and/or Radarsat. In FY 1983 we will be studying potential options so that we may have access to these various data sources.

QUESTION A-18:

What are NASA's long range plans for the Technology Utilization program? NASA's FY 1983 budget request would appear to indicate plans to phaseout this program. Is this correct?

ANSWER A-18:

NASA does not plan to phaseout its Technology Utilization Program. On the contrary, NASA is strongly committed to the objectives of technology transfer and will continue in its effort to maximize the effective utilization of aerospace-developed technology in the public and private sectors of the economy. It is felt, however, that NASA can maintain an effective program through consolidation, centralization and modernization techniques at a lower cost than in the past.

QUESTION A-19:

NASA recently justified waiving the requirements of the

Stevenson-Wydler Technology Innovation Act based on the Technology Utilization activities and yet the Technology Utilization budget shows a downward trend from $12.1 million in 1980 to $4 million in 1984. How do you explain the conflict between this waiver justification on the one hand and the budget trend on the other?

ANSWER A-19:

While there is a significant downward budgetary trend in NASA's Technology Utilization program, NASA will continue to provide U.S. industry available technical information. There is continuous interaction between NASA scientists and engineers throughout NASA and potential users of aerospace technology in industry and the public sector. Because of the nature of research and development activities, the transfer of technology to industry and the public sector by NASA is a continuous and ongoing way of doing business.

QUESTION A-20

a. How is NASA implementing the "small business innovation research" legislation?

b. How is this managed? What office has responsibility?

ANSWER A-20:

a. Overall management of the Small Business Innovation Research (SBIR) program has been assigned to the Office of Aeronautics and Space Technology. Funding, as set forth under P.L. 97-219, will be allotted to this program as a percentage of the funds budgeted for R&D in the various programs of NASA. These funds will be awarded based on the merit of individual proposals which will be technically evaluated at the NASA centers. Solicitations for research supportive of NASA's programs and recommended by the NASA centers and Headquarters program offices will be distributed annually to small businesses. The Headquarters program office will make final selections of awards based on the center's recommendations, but also considering program balance and available funding. Contract awards will be made by individual center procurement offices. Program reporting required by P.L. 97-219 is a Headquarters responsibility.

b. The Associate Administrator for Aeronautics and Space Technology (OAST) is responsible for the overall administration of the NASA SBIR program. The Manager of SBIR Program Office in OAST manages the day-to-day activities in this program. An SBIR Working Group consisting of key individuals from each NASA program

office and center advises on the technical content and administration of the SBIR program.

QUESTION A-21:

a. What are NASA's plans regarding the IRTF facility on Mauna Kea?

b. Is NASA still pursuing discussions regarding the transfer of IRTF to NSF?

ANSWER A -21:

a. The IRTF will remain operational in FY 1983 with NASA funding as directed and supported by Congress. Operational funds for the IRTF in FY 1984 are included as part of the FY 1984 planetary research and analysis budget request.

b. Discussions are continuing with the National Science Foundation concerning future operational support of the IRTF. Both agencies need the IRTF to remain operational so that their respective observing time requirements can be met. A final decision on the question of which agency will provide operational support of the IRTF is expected prior to the FY 1985 budget preparation.

QUESTION A-22:

How does the FY 1984 budget impact the Pioneer spacecraft?

ANSWER A-22:

The FY 1984 budget request includes funding for the continued operation of the Pioneer Venus and Pioneer 6-11 spacecraft and the associated analysis of the collected data.

QUESTION A-23:

a. How would you characterize the workload at the various centers?

b. Are the various centers capable of taking on new projects? Or are they overstaffed given that we have no new projects?

ANSWER A-23:

a. Our Centers are being well utilized. Much of the work in aeronautics and space technology is of a basis, fundamental nature, performed in-house by civil

service employees who represent a unique national research capability. The in-house research efforts are complemented by contracted research, and a small amount of contracted project activity.

The Space Shuttle flight rate is increasing. DDT&E is coming to an end but some changes and improvements will continue to be made. Production is building up, and we are planning and implementing the transition to the STS operations era. Space science activity is increasing in several areas.

b. NASA centers are not overstaffed. In research and development, some new work in the form of studies, advanced development, research and technology, and even project definition, must be undertaken by every center each year. Such work is necessary if a center is to retain its technical edge and assure that NASA has access to an adequate technical and economic decision base. In addition, we have a planetary new start (Venus Radar Mapper) and a significant increase in aeronautics funding, both for R&D and Construction of Facilities, in the FY 1984 budget.

A basic objective of NASA management is to maintain an appropriate balance between in-house and contracted activity. The FY 1984 program budget reflects that objective.

QUESTION A-24:

What are your plans with regard to NASA's future role in energy R&D reimbursable activities?

ANSWER A-24:

In FY 1984, NASA will continue to support those energy programs which were initiated in prior years, and which the DOE or other sponsoring agencies desire NASA to continue. We intend to complete our previous commitments as efficiently as possible to ensure the integrity of the Government investment made to date. For the future, it will be our policy to concentrate on energy programs which have objectives which are synergistic with NASA's aeronautics and space programs.

QUESTION A-25:

There is about a three year gap in Explorer launches between one in 1984 and one in 1987. Which will be launched in 1984? In 1987? Why is there such a gap?

ANSWER A-25:

Our current schedule includes the launch of the Active

Magnetospheric Particle Tracer Experiment (AMPTE) in 1984. The Roentgen Satellite (ROSAT), which is a German satellite, will be launched in 1987 and the United States is developing instrumentation to be flown on that satellite.

The Cosmic Background Explorer (COBE), which was initiated in FY 1982, and the Extreme Ultraviolet Explorer (EUVE), which will be initiated in FY 1984, are also targeted for launch in 1987/88 timeframe. The major reason for the amount of time between launches is because of technical problems which were encountered in the development of the Infrared Astronomical Satellite (IRAS) which delayed the launch until January 1983 and delayed the initiation of AMPTE, COBE and EUVE. The IRAS spacecraft and instruments are now operating very successful, therefore, NASA now feels comfortable in initiating EUVE in FY 1984.

QUESTION A-26:

Are you going to make a new start on the Advanced Communications Technology Satellite? If so, why do funds for Communications drop from $32.4 million in 1983 to $21.1 million in 1984?

ANSWER A-26:

NASA has included the Advanced Communication Satellite (ACTS) as a new initiative in the FY 1984 budget request. The funding decrease from FY 1983 to FY 1984 reflects a request for the FY 1984 funding necessary to support an ACTS prime contract award in FY 1984 leading to a launch in 1988. The contract award is based on the expectation that industry will make a substantial contribution to ACTS development. Funding available in FY 1983 and FY 1984 will be phased in a manner to support the 1988 launch schedule.

QUESTION A-27:

Consider our ongoing planetary missions--take Voyagers I and II which have visited Saturn and Jupiter and are taking data as they speed on toward Uranus and the edge of the solar system (the hellopause). There are funds to support these missions in "Tracking and Data" and funds to support them in the Mission Operations and Data Analysis line of "Planetary Exploration". How are these two separate funds accounted for? How are they differentiated?

ANSWER A-27:

Planetary Mission Operations and Data Analysis:

	FY82	FY83	FY84
Voyager Extended Operations	17.2	17.4	19.1

Tracking and Data Acquisition (Voyager Extended Operations Support):

FY82	FY83	FY84
1.7	2.5	1.1

The Voyager Extended Operations funding within the Planetary Mission Operations and Data Anaylsis budget provides for the actual data collection from the Voyager spacecraft and for the analysis of that data.

The Tracking and Data Acquisition funding shown above is the Voyager-unique requirements for the Extended Operations and is required to actually track the spacecraft so that it may be given commands required for specific operational and scientific requirements.

QUESTION A-28:

The Upper Atmosphere Research Satellite program has been carried on the book for years to develop instruments. Your own budget book states it is the "next logical step" (page RD 7-23) in upper atmosphere research.

a. Including 1984, how much money has gone into this satellite so far (for instruments)? [Answer: About $40 million]

b. When will you make a commitment to a satellite - i.e. to a new start?

c. Or when will you decide not to have a new start and to stop developing instruments for a satellite that will never be built?

d. Was the Upper Atmosphere Research Satellite a requested new start?

ANSWER A-28:

a. Including funding requested in FY 1984, about $40 million will have been spent on instruments and mission definition studies. With this mission, the instruments are the technology drivers and the Upper Atmosphere Research Satellite Experiments funding has enabled us to complete detailed study of these

instruments. During FY 1982, 1983, and 1984, the mission implementation plan will have undergone considerable definition which will hopefully improve the understanding of the exact spacecraft requirements; thus allowing a more reliable estimate of the total cost of the mission.

b. It is currently our plan to consider the UARS mission as a candidate in the FY 1985 budget.

c. Since the instruments now under development are the technological drivers for this mission, they are also the schedule and cost drivers. Therefore, early detailed definition of the instruments was required.

d. A UARS mission was recommended as a FY 1984 new initiative.

QUESTION A-29:

a. How big is your reimbursable budget for 1983? For 1984?

b. How much of that is for the launch of expendable rockets, such as Scout and Delta? Of this, how much is Government, how much commercial?

c. How much is for Shuttle launches?

d. Do these funds stay with NASA or are they returned to the general fund in the Treasury?

ANSWER A-29:

a. NASA does not budget for reimbursements as such. We estimate the amounts which are projected to be received from a large number of sources. The amounts we will actually receive are dependent on a large number of factors including actions on the funding request of other agencies and decisions of private business concerns and of foreign governments. Our current estimates of reimbursable orders are about $990 million for FY 1983 and $985 million for FY 1984. These are planning estimates based on NASA projections after surveying potential reimbursable customers. These projections are subject to change based on presidential allowances, congressional authorization and appropriation action, and economic and financial conditions.

b. The table below shows the anticipated reimbursements for expendable launch vehicles by U.S. Government and non U.S. Government sources in millions of dollars.

	FY83	FY84
U.S. Federal Government	117	101
Non-Federal Sources	142	79
Total	259	180

c. Reimbursements for Space Shuttle operations are anticipated to be about $150 million in FY 1983 and $260 million in FY 1984.

d. Most of these funds are applied to contractor activities and in that sense they neither stay with NASA nor are they returned to the Treasury. The funds are used to pay for the materials and services covered by the reimbursable order or agreement.

QUESTION A-30:

There is some talk that all our space remote sensing satellites will be commercialized, i.e. be transferred to the private sector. It also seems that there is a very good chance that only one company will take over all the systems.

If there is only one company, will NASA continue to do research in remote sensing technology?

ANSWER A-30:

Whatever the outcome of the examination of the roles of Government and the private sector in operational remote sensing, it is expected that NASA will continue to be active in remote sensing research to pursue scientific research with a global perspective and to test the findings from that research for applications on a global basis. The research will be long-term in nature, and oriented toward maximizing the scientific understanding of remotely sensed data. NASA will also pursue development of new sensors like the Multispectral Linear Array to further the technology of remote sensing.

QUESTION A-31:

a. How many Shuttle launches are anticipated for FY 1983?

b. What is the anticipated cost of these launches--that is, what is cost of Shuttle operations [about $1.5 billion] plus the NASA in-house salary costs?

c. What is the cost-per-flight using these numbers? [Around $200 million]

d. How does this cost compare with the price NASA will charge users?

ANSWER A-31:

a. There are five Shuttle launches anticipated for FY 1983.

b. Total operations costs for a Shuttle flight consists of costs for the consumable items used in flight plus the operations support cost for launching and flying the mission. These total operations costs for the five 1983 Shuttle launches are estimated at about $1.5 billion (real year dollars), including an allocation of R&PM.

c. The average cost per flight is in the range of $250 to $300 million (real year dollars) per flight, including an allocation of R&PM costs.

d. The standard launch services charge for a full or dedicated Shuttle launch for the initial three years of operations (FY 1983-FY 1985) was established in 1977 at $18 million (FY 1975 dollars), subject to escalation. This amount was based on the projected average cost over an operational period of twelve years and about 550 flights. To this standard price is added a reflight guarantee premium of $271,000 (FY 1975 dollars) and a use fee of $4.3 million based on a pro rata share of the depreciation of facilities and equipment and the amortization of the investment in the orbiter fleet. The total price--when escalated to FY 1983 dollars is about $42 million. The price that NASA charges individual users is proportional to the amount of the Shuttle bay they use; typically, for an average communications satellite this is about one-fifth to one-fourth of a Shuttle bay. The approach of establishing a price for early users based on the projected average over the entire twelve year period was to avoid burdening the early customers with the higher costs anticipated during the transition from Shuttle development to operations.

QUESTION A-32:

Mr. Beggs, in your statement at the press conference on the NASA budget (January 31, 1982) you said that "this budget provides an increase in funding for...work done principally at our universities."

In 1981 you funded $191.1 million of work at universities; in 1982, $185.6 million; and in 1983, $193.2 million.

What kind of support will the universities receive this year? Where will we find this in your budget?

ANSWER A-32:

In FY 1984, NASA expects to provide approximately $205-210 million to educational institutions for research activities. This funding is spread across the FY 1984 NASA budget request for Research and Development; it is not located in one distinct area of the budget. The largest portion of the FY 1984 estimated funding to educational institutions will be provided from the Space Science and Applications budget request.

QUESTION A-33:

Mr. Beggs, in your press release of January 31 you draw attention to the fact that there are plans for modest expansion in space technology, physics, astronomy, and aeronautics research and technology. Is this trend likely to continue in the future and is it NASA's intention to concentrate more resources on space R&D and less on mature technology and operational activities?

ANSWER A-33:

The projections for future years carried in the FY 1984 budget continue the pattern of increase in the funding levels for space technology, space science and applications and aeronautics. The present projections reflect an increase in FY 1985 of about 14 percent over the FY 1984 plan, I expect NASA to continue and to emphasize its role as a research and development agency.

QUESTION A-34:

The FY 1983 NASA operating plan and the 1984 budget estimate for the Space Research and Technology Base show a shift in emphasis toward controls and human factors, and platform systems research and technology. Would you please explain the reasons behind these moves?

ANSWER A-34:

The shifts in emphasis are part of the continual process of maintaining an Research and Technology Base that is current and relevant to potential future Agency missions and national priorities. In this regard, there is a clear trend toward large space platform structures applicable to both unmanned and potential manned systems such as space station. Funding for the space controls research and technology program was increased because it was recognized to be a high payoff area in which technology advances could make a dramatic impact on capability for control of earth-orbiting structures such as large antennas, planetary spacecraft, and platform systems. An R&T Base program

in human factors was initiated to provide for research directed at extending human capabilities in space. This program, expanded in FY 1984, will provide a generic technology base for improved man-machine interfaces in future spacecraft systems. The platform tasks include technology augmentations supporting space operations such as in-orbit repair, service and test, and development of systems simulation tools.

QUESTION A-35:

One of the objectives of NASA's Space Research and Technology program is to support and promote commercial space interests. Does NASA plan any new initiatives to encourage more private/public sector participation in developing a technology base for long-term applications, i.e., beyond a five-year horizon?

ANSWER A-35:

While no Space Research and Technology initiatives are requested in FY 1984 to specifically support and promote commercial space interests, this important objective is addressed in the Space Research and Technology Long Range Plan. The potential for increased NASA contributions in technology supporting both the spacecraft user and manufacturing interests are being evaluated. Within the current Space R&T program, long-range research efforts such as that in 30/20 GHz communications interests. Other areas of the program, such as stationkeeping propulsion, remote sensing, power systems, and advanced materials research serve private sector interest, although perhaps less directly. In all of these areas, private sector participation is encouraged through cooperative Independent Research and Development efforts and contracts. The Office of Space Science and Applications programs such as the FY 1984 proposed Advanced Communications Technology Satellites (ACTS) are a more direct link for transfer of technology applications to commercial systems; technology research from the Office of Aeronautics and Space Technology program finds its way into flight systems experiments such as ACTS. It is NASA's intent to continue and to encourage more private/public sector participation in long-term R&T.

QUESTION A-36:

Mr. Beggs, as the Space Shuttle capability continues to mature, there will be less need for a NASA inventory of expendable launch vehicles. Can you tell us what NASA plans to do with expendable launch vehicles? Do you plan the same policy of format for a Shuttle vehicle?

ANSWER A-36:

NASA's long range planning does not include the need for expendable launch vehicles as we know them today. Our current launch vehicles will be used up in this decade for firm user requirements.

NASA has received a number of proposals from interested private sector organizations for the commercialization of expendable launch vehicles. We are studying these proposals at this time. The policy and practical issues raised by commercialization of expendable launch vehicles should be helpful if the Shuttle is eventually commercialized.

QUESTION A-37:

Mr. Beggs, a few years down the road do you envision the Air Force procuring their own Space Shuttle fleet?

ANSWER A-37:

I do not believe that this will occur in the near future. We do not foresee the need for additional capability for civil sector and/or national security requirements at this time. Nevertheless, I would not rule out the possibility that at some later time the need will develop within the Department of Defense for its own Space Shuttle fleet.

QUESTION A-38:

Mr. Beggs, with the advent of the Tracking and Data Relay Satellite System (TDRSS), the costs to NASA has significantly increased in the FY 1984 budget ($499 million to $700 million). Would you explain this increase and also what kind of numbers we can look forward to in the future since the OTDA budget was projected to go down with the inclusion of TDRSS? TDRSS would allow the closing of approximately eight/ nine ground stations.

ANSWER A-38:

The increase between FY 1983 and FY 1984 is due primarily to a full year's funding for TDRSS service and the inclusion of loan payments to the Federal Financing Bank (FFB). This item accounts for approximately $192 million of the $201 million increase. Other increases due to escalation and the consolidation of budget responsibility in the Office of Space Tracking and Data Systems (OSTDS) for Program Support Communictions (PSC) are partially offset by a funding decrease associated with the close down of Space Tracking and Data Network (STDN) facilities

during FY 1984 and a reduced funding level for the network reconfiguration program in the Deep Space Network (DSN) implementation program.

With regard to the out year budget levels, the OSTDS budget in support of the ongoing approved program is expected to drop from the FY 1984 level when measured in FY 1984 constant dollars. On a FY 1984 constant dollar basis, the OSTDS budget, in support of currently approved programs, would be reduced by approximately 80 to 100 million dollars by FY 1988. With the current ground tracking network, only about 15 percent coverage can be provided for a typical satellite orbit as compared with the visibility provided by the TDRSS which would provide about 85 percent coverage. Therefore, the Tracking and Data Acquisition support capability will be significantly enhanced by an operational TDRSS.

QUESTION A-39:

Can you address the underlying philosophy behind the priorities presented in the 1984 aeronautics program?

ANSWER A-39:

The philosophy is consistent with the policies set forth in the recently completed and reported OSTP study on the Government role in support of aeronautical R&T. The program proposed for FY 1984 is a positive, constructive step in the implementation of those policies. It assures that we will be able to modernize, improve, and extend our aeronautical test facility and computational capabilities to be a more productive contributor in the R&D process. It provides a unique opportunity to hire top quality scientist and engineering graduates for our research centers. It allows high priority technology needs and opportunities to be pursued with appropriate emphasis on the initial phases of the R&D process. And, it strengthens our partnerships with industry and academia in seeking the full participation of the R&D community.

QUESTION A-40:

Both subsonic aircraft systems technology and advanced propulsion system technology took large cuts in the 1984 budget. Is this because these programs will be completed this year, or are these programs that fell out because of priorities?

ANSWER A-40:

Some of the program elements referred to were scheduled to be completed with FY 1983 funding while some others were considered to be of lower priority within the overall objectives of the program.

In the area of subsonic aircraft systems technology, the Energy Efficient Transport and the Composite Primary Aircraft Structures programs are scheduled to be completed in FY 1983. In the advanced propulsion systems technology area, the Energy Efficient Engine (EEE) program will also be completed as planned in FY 1983.

QUESTION A-41:

NASA conducts a number of programs with other agencies. Could you tell us approximately how much additional funding is available through joint program? For example, what percent of the funding for the forward swept wing program comes from DARPA?

ANSWER A-41:

NASA has many cooperative programs worked jointly with the military, civil agencies, and/or industry in which the technical expertise and facilities of our research centers are necessary for their successful completion. There are two methods under which these participants make resources available to NASA to conduct joint programs. The first is reimbursement to NASA in which funds are provided to NASA from the other party to perform agreed upon work. The amount projected for FY 1984 under this kind of arrangement is about $25 million in aeronautics.

The second method of providing resources, and the most common in joint programs, is for the other party to provide resources in the form of services, wind tunnel, models, aircraft, or other equipment. In this case, the other party retains control of their own funds and there is no dollar transfer.

In most aeronautics cases, funding is less important than the test equipment, such as models or aircraft for flight research. A prime example is the DARPA/NASA forward swept wing program. In this case, all the wind tunnel models required for the vehicle program are supplied by DARPA, but because of its unique capability, NASA conducts the required testing in the Langley 30 x 60 foot tunnel. NASA is funding a research model to be tested in the National Transonic Facility at Langley to obtain data at high Reynolds number to be compared with flight test results. At the present time, DARPA is funding the construction of two X-29 flight vehicles at an estimated cost of $82.5 million. NASA is adding $1.8 million over several fiscal years for special flight test instrumentation and will conduct the flight test program scheduled to begin in 1984 at the Dryden Flight Research Facility.

In space technology programs, the commonality of requirements in many of the disciplines has fostered cooperative efforts between NASA centers and Air Force laboratories. A formal Space Technology Interdependency Group aids the process of jointly planned programs wherein each participant manages and funds its respective program elements. The approach does not require funding transfers; it assures synergism and avoids duplication of effort. Similar, though less formally structured, cooperative programs are pursued with other elements of the DOD and with other Agencies.

QUESTION A-42:

What are NASA's plans for future use of the White Sands Harbor, in both near and long term.

ANSWER A-42:

The White Sands test facility will continue to be used as a primary location for Shuttle training aircraft activity. In addition, it will serve as an alternate landing site for lakebed landings when these are required and as a contingency landing site for all Columbia missions after STS-6 (i.e., STS-8, 9, 15, and 19) until Heads-Up Display is installed into Columbia.

Mr. BEGGS. Mr. Chairman, having discussed some of the important highlights, I would now be happy to answer any questions that you and other members of the committee might have. Also, Mr. Chairman, with your permission, I would like to read for the record a Presidential policy that has recently been established with respect to the shuttle program, if I may read that at this point.

Mr. FUQUA. Certainly.

Mr. BEGGS [reading]:

After reviewing various options presented by the Senior Interagency Group—Space, I have decided that maintaining Orbiter production capability is in the best interests of the Nation. This objective will be achieved through the production of structural and component spares necessary to insure that the Nation can operate the four-Orbiter fleet in a robust manner. Those spares will provide the necessary assurance that Shuttle operations will continue in the face of minor problems, modifications, or other periods of extended Orbiter outages.

While this decision does not constitute approval of procurement of a fifth Orbiter in fiscal year 1984, it does partially preserve this option for a future decision should optimistic estimates of demand materialize and other conditions dictate. It is my intent that the full potential of the Shuttle concept as originally envisioned is achieved and commercialization of space becomes a reality.

The National Aeronautics and Space Administration is directed to submit to the Office of Management and Budget for inclusion in the fiscal year 1984 budget a request for procurement of the structural and component spares that will carry out this decision.

Mr. FUQUA. Thank you very much. On that same subject, could you provide us with the requirements and a production cost analysis of a fifth orbiter based on initiating production by fiscal years 1983 and 1984 compared say with fiscal year 1986, and including the implications of the loss of an orbiter and the implica-

tion of an orbiter being out of service for an extended period of time, and the implications regarding maintenance of a subcontractor base?

Mr. BEGGS. Yes, sir. We are looking right now at just those issues, and we will be happy to supply that to you, sir.

Mr. FUQUA. You can supply that then for the record?

Mr. BEGGS. We can supply it for the record; however, I can give you a brief overview of what I know about it if you wish, sir.

Mr. FUQUA. If you want to supply it for the record, we can save time by doing that. We need that as soon as we can get it or as expeditiously as we can.

Mr. BEGGS. Yes, sir.

[The information follows:]

Over the past year, NASA has intensely studied the need for additional orbiters with emphasis on the requirement for a fifth orbiter. This examination focused on impacts of the loss or extended downtime of one of the currently authorized four orbiter fleet and on the likelihood of projections of future growth being realized beyond the capabilities of the four orbiter fleet.

The results of the studies have shown that four orbiters can more than meet the mission manifest requirements for at least the remainder of this decade. However, a theme emerging from the studies was the need for a measure of assurance to accommodate unscheduled maintenance, system upgrades, aborts, and accidents causing extensive damage or loss of an orbiter.

The proposed orbiter structural spares will provide the assurance necessary for the nation to operate the four orbiter fleet in a robust manner. The fiscal year 1984 budget includes $100 million of a planned total of $420 million for the procurement of orbiter structural spares. These structural and component spares will provide the necessary assurance that Shuttle operations will continue in the face of minor problems, modifications, or other periods of extended orbiter outages.

Another important benefit to procuring the structural spares is the protection of our orbiter production capability. Following delivery of the OV-104 hardware, many structural and component subcontractors would otherwise be closing down their orbiter lines; this action preserves major areas of production capability for an additional 1-2 years, depending on the element.

An fiscal year 1984 go-ahead for OV-105 would provide a late 1988 or early 1989 delivery at an estimated cost for the orbiter systems alone of about $1.8 billion. However, it should be recognized that there are further additional costs associated with the procurement of a fifth orbiter dependent on its eventual use and supporting system requirements and capabilities. Initiating procurement of a fifth orbiter in fiscal year 1986 would slip the delivery, but with the production of these structural spares the lead time to procure an additional orbiter, if needed, would be reduced by about 1-2 years. The specific effect of the procurement of these structural spares on costs and schedules of a possible follow-on orbiter procurement have not been determined.

Mr. FUQUA. In the memorandum that the President signed, I gather there was no definitive amount of funds. That is something that you would determine and then submit to the OMB?

Mr. BEGGS. We have given OMB a request for about $400 million for primary structural spares.

Mr. FUQUA. There is only $100 million in the budget.

Mr. BEGGS. $100 million this year. The runout is about $400 million. It will be spread over the next 4 fiscal years. We will buy almost all of the primary structure as spares, and that will provide us with the necessary backup to repair an orbiter if it is damaged in operation. Of course, it will keep the production line open for an additional period of time, we believe perhaps as much as a year. Mr. Chairman, if I may amplify that, that is in the budget as it has been submitted.

Mr. FUQUA. How much additional funds?

Mr. BEGGS. There is $100 million in fiscal year 1984 and, I believe, $120 million in both fiscal years 1985 and 1986 and the remainder in fiscal year 1987.

Mr. FUQUA. On the space telescope, when we had hearings and briefings in October of this past year, we were told that there was no problem, everything is running smooth. Now we are informed that there is going to be a slip and a considerable amount of overrun. Is it a technical problem or a management problem?

Mr. BEGGS. It is both. It is a technical problem because what we are trying to do is state-of-the-art activity. When we spoke and wrote to the committee late last year, it was our feeling that the problems were management and that we could complete it as originally scheduled and budgeted. I was recently informed that this is not entirely the case. I have taken actions to make a complete review and I plan to visit Perkin-Elmer, one of the two major associate contractors, later this month. After I have had a chance to review the situation there, I will then proceed to the other major associate contractor, Lockheed, to review the situation there. After this review, I will be in a better position to come up with an action plan.

The good news is that the primary mirror for the space telescope was completed and exceeds the specifications. It is a very good piece of equipment. The problem we have run into is in the electronics and in the pointing of the instrument. Perkin-Elmer, in particular, has run into serious technical problems in that area. It appears that the problem will significantly impact the schedule. How much it will impact the budget cannot be assessed through until we have completed the review. I believe that the problems we have are manageable, but they are serious. I don't want to underestimate them in any way.

Mr. FUQUA. Mr. Lujan?

Mr. LUJAN. Thank you, Mr. Chairman.

Let me ask first something that has nothing to do with this hearing, but there is a leftover launching platform, a large skyscraper sort of thing that the National Park Service is interested in preserving and you are getting ready to tear it down. As a matter of fact, I understand you had a contract that it would be torn down. I have contacted some of the officials in NASA, although I hadn't talked to you about it directly. Are you familiar with that?

Mr. BEGGS. Yes, I am. That is the third mobile launcher platform. We had planned to tear off the large gantry structure that was used for the Apollo program, and convert it into a mobile launch platform for the shuttle. We have recently received bids to do that. The bids were issued so that the structure would simply be destroyed. There is historical value in it, I realize, but the problem that we are confronted with is that today a complete preservation job on the structure would take a significant length of time and would impact our schedule. We are looking, though, very carefully at an approach in which we can cut it, lift that whole structure off, and set it aside for possible future refurbishment as a historical artifact. I don't know yet whether we can do that, but we are going to try.

Mr. LUJAN. Are they talking about a pad or a tower?

Mr. BEGGS. It is a fairly complex tower structure. What the Park Service is talking about is the tower that was on that big mobile launcher platform—the big tractor that crawls out with the load on it. There is a lot of interest amongst the folks who are responsible for displaying the historical artifacts to have access to the tower. We will try to give it to them, but it is not going to be easy.

Mr. NELSON. Would the gentleman yield for a question?

Mr. LUJAN. Sure.

Mr. NELSON. When would that decision be forthcoming?

Mr. BEGGS. Within the next couple of weeks, Mr. Nelson.

Mr. LUJAN. If you are going to be launching four orbiters, aren't you going to need those movable launch pads or is this not——

Mr. BEGGS. What we have done in this case is simply made a flat bed out of that mobile launcher where we stacked—we have put the stack of the shuttle on that, and the servicing facilities are permanent out on the pad. The purpose of that was as a means of simplifying and reducing the amount of labor and cost in moving from one launch to the next.

We have converted two of the MLP's, the mobile launcher platforms. This is the third and the last one we have, and it is necessary for the maintenance of the schedule over the next several years.

Mr. LUJAN. How is a decision like that made? It appears the Interior Department would like to have this and it is very important in their function, but NASA doesn't see it as that sort of thing, NASA sees it as an efficiency move to tear down the building. How do you resolve that? Just Jim Beggs saying I am not going to do it?

Mr. BEGGS. No. We did not consider that that piece of equipment had that kind of historical value until somebody pointed it out to us. We went ahead, as we generally do in cases like this, and looked primarily at scheduling costs. To do the job in the way that they would like to have it done would have a severe impact on our schedule. But, as I said, it may be possible to simply lift it off and then wait for a later date to refurbish it for display.

Mr. LUJAN. One area that I want to get into—I know we don't have very much time here—but you talk about the energy work that NASA does and that in the future will be doing it with energy programs which have objectives which are synergistic with NASA aeronautics and space programs.

I understand you will finish the work, like the ceramic work that you are doing, engines, that sort of thing, but that under this criteria that kind of a program would not be started in the future because it may not——

Mr. BEGGS. The ceramic work is one that was of long-term interest to us and we would like to see that program continue. There is work that will terminate from time to time that probably would not be reinitiated. What we have done is negotiate with the Department of Energy and we have assured them that anything that they have ongoing with us would continue to an appropriate termination point However, work that we agree is mutually of interest to both the Department of Energy and ourselves would be continued for as long as they wish to fund it.

The problem that we are running into is that we are diverting portions of our manpower to programs which really don't have

direct value to the Agency, while at the same time trying to bring manpower down. As I mentioned in my statement, we have stabilized our manpower at about 21,000, and we are able to manage within that figure. But the addition of significant programs means that we have to take from our manpower ceiling, because there are no positions that come with the work. They do provide money, and we are pleased to have the research funds, particularly when they help us pursue our objectives.

Mr. LUJAN. Thank you.

Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Brown.

Mr. BROWN. Thank you, Mr. Chairman, and it is a pleasure to have the NASA so well represented here this afternoon.

Mr. Beggs, you spoke in glowing terms of the results of Landsat-D or Landsat-4, the fact that it seems to be achieving or surpassing expectations with regard to the data being returned, and I recall that we had some interesting data returned by photography from one of the recent shuttle flights.

If I recall correctly, and I don't have it with me, there was a series of articles in Science that indicated some rather startling results from that photography including some archeological indications in Egypt. Am I correct in that?

Mr. BEGGS. Yes. That was the so-called SIR-A, a shuttle imaging radar which we flew on the second shuttle mission.

Mr. BROWN. I mention this to stress my continued interest in Earth observation activities. We have a number of unresolved policies in that area which I would like to see some progress made on, and I would like to get your comments on it. We have no plans for a follow-on to Landsat 4, do we?

Mr. BEGGS. We have one more.

Mr. BROWN. We have D-prime in the middle, but nothing beyond that?

Mr. BEGGS. We have nothing beyond that.

Mr. BROWN. Where do we stand on the plans to shed Landsat from NASA and spin it off to private operation or whatever we are going to do with it?

Mr. BEGGS. We have transferred the operational responsibility for that system to the Department of Commerce, NOAA, as of January 31, 1983, with the exception of the work that continues on research and development aspects of Landsat-4 and D-prime. That work most particularly relates to the thematic mapper in accordance with the plan.

I understand that NOAA is developing a plan to try to spin that off to a private sector company, but I am not privy to their plans.

Mr. BROWN. That is not in your bailiwick now?

Mr. BEGGS. It is their system now.

Mr. BROWN. Well, we will take that up with NOAA when we get around to them, but what I am really seeking for is to understand the administration's posture with regard to this emerging and very significant new technology.

As a matter of general principle, you have indicated that as a result of an indepth study of the relative goal of the Federal Government aeronautics research, you are committed to continuing with a strong partnership operation in that field. Have we made

any similar study with regard to Earth observation activities and its commercial possibilities or the satellite communication field and its potential in order to elucidate a long-range progam cooperative with private industry that would be in the best interests of the Nation?

Mr. BEGGS. I believe, the intent of the NOAA plan is to try to develop a cooperative relationship with the private sector organization. The policy is clear with respect to research and development, Mr. Brown. We still have the charter to pursue the R&D efforts both in the Earth remote sensing area and in the communciations area. In the base program, we have funds to continue that research.

We will again fly, for example, that shuttle imaging radar some time in the next year or so, and reexamine what we can get from an expansion of that activity. We are doing a good deal of research and looking forward. I can't say that we have looked hard at the commercial potential of the remote sensing area, however.

Mr. BROWN. Well, Mr. Beggs, a charter which does not include in it looking beyond Landsat-D-prime, and which leaves you ambiguous about the future of the program—and I don't expect you necessarily to be able to speak for the administration, and obviously, they haven't decided what they are going to do, but what I am saying is when you couple that with the funding for advanced communication research, which has gone up and down over the years, then I am not impressed by the long range firmness of that charter that you speak of.

Mr. BEGGS. I agree that we have had an off-and on-relationship with the satellite communications technology over the years. We do have a budget to continue the R&D work in communications in fiscal year 1984 and will continue to put that money in the budget.

The question that this eventually comes down to is the demonstration area which is the actual flying and vertification of the technology. As I mentioned in my statement, our intent is to try to get a joint cooperative program with industry to fly some of the advanced technology in the hopes that we can bring it to commercial reality more quickly. If we can succeed in doing that, I think we can shorten the leadtime from the laboratory to commercial reality which is really our objective in that program.

Mr. BROWN. We will pursue that with you later.

Dr. Mark.

Dr. MARK. Mr. Brown, one point that ought to be made on Landsat is that we have a developed technology which has been turned over to NOAA. NOAA will now turn around and try to interest industry in it. You mentioned an important example of a new technology that we are flying now and we are going to continue to fly in Earth observation, namely the imaging radars. Those radars are not yet ready to fly on the same basis as Landsat is flying nor can it be turned over for operation. But, it is an example of the kind of new technologies that we are going to develop in the Earth observation area.

Mr. BROWN. Dr. Mark, I don't agree with your use of the term "developed technology." I am referring to the totality of Earth observation technologies. They are developing. They have a long way

to go and you and the Agency don't seem to know what direction they ought to go in.

In the meantime, we are getting beat out by others that seem to have a little better sense of direction, which is the thrust of my bias in this area.

Mr. FUQUA. Mr. Volkmer.

Mr. VOLKMER. Thank you, Mr. Chairman.

I, too, am interested in the information that the chairman requested with regard to the fifth orbiter as to timeframe. I would like to know if we could expect to have that information say within the next couple of weeks, if that is too short a timeframe.

Mr. BEGGS. I would like to have to the end of the month, if I could have it.

Mr. VOLKMER. If that is necessary.

Mr. BEGGS. I will try to get it as quickly as possible.

Mr. VOLKMER. When can we expect a report on the telescope and the cost problems with that?

Mr. BEGGS. Some time in March after I have a chance to meet with the two major contractors on that.

Mr. VOLKMER. The other thing I notice that we are continuing to have studies on the question of a space station, but I also note that there seems to be a firmness in your statement that this does not mean that we are proposing a space station; is that correct?

Mr. BEGGS. That is correct, sir.

Mr. VOLKMER. But you are not either denying that it may be a—something that you all want to have in the future?

Mr. BEGGS. Both Dr. Mark and I are on record in that we think that is the next logical step. In the way in which programs of this type are developed, you want to be awfully sure that what you are proposing has a solid base both in the technology and in the systems development activities.

I would remind the committee that in the case of the space shuttle, we first started conducting shuttle studies back in 1967. It took us about 5 years before we finally got the program underway, and we did a lot of work in assuring ourselves that the technology base was there so that the program would be a success. Even then, we found that we probably would have liked to have done more work in outlining the details of the shuttle.

In this case, we are following the recommendations of Don Hearth, the Director of the Langley Research Center, to fully define a proposed project more thoroughly before proceeding to development. This way, a station proposal could be presented to the President as something that we have confidence in. When we do that, it is our hope that it could go forward, but it has not yet gotten to the point where we could even propose it as a new start.

We are now spending some money. We are doing a lot of technology development work. We have initiated a number of studies looking at mission requirements. In another year or so, we will be prepared to firm up an option which we can price with confidence.

Mr. VOLKMER. In other words, you still say that there is a positive movement in this regard?

Mr. BEGGS. In the Agency there is, yes.

Mr. VOLKMER. The other area that I would like to ask you about is what I call the privatizing basically of the space shuttle such as,

to get back to the question of the fifth orbiter and the space trans proposals, the question of licensing expendable launch vehicles, et cetera, that are being proposed. First, on the space trans proposal, do you have any idea when you would be able to come to any conclusion?

Mr. BEGGS. They have gone back to the drawing board. There have been some recent changes in the ownership of the company or of the venture that had been organized early on. We have had a number of discussions with the principals of that company. There are a number of problems that have cropped up in those discussions with respect to the financing that they would make available and the way in which they would enter into an agreement with us to proceed with the construction of the fifth orbiter. They have gone back once again to review exactly what they would propose. As I say, there have been some recent changes with some new interests coming into it, and we, I guess, are at the point where we are waiting for their revised proposal on a fifth orbiter or some other basis to share in the capacity of the shuttle system.

With respect to the expendable launch vehicle investigations, we are proceeding to develop a policy position with respect to the use by anyone who would want to take over one or more of the expendable launch systems. We would have to make available, of course, the launch facilities, which we own, and the Air Force has to reach a similar solution with respect to the range safety and the downrange services which are required for any launch. I think within a matter of another 4 or 5 months, we should have a position that would allow a commercial organization to come in to make a proposal to take over an expendable line and operate it.

Mr. VOLKMER. Thank you very much.

Thank you, Mr. Chairman.

Mr. FUQUA. Thank you.

Mr. McGrath?

Mr. MCGRATH. Thank you, Mr. Chairman.

Mr. Beggs and Dr. Mark, on or about June 15 of last year, we had a hearing on the need for a fifth orbiter. I think at that time we tried to elicit from you your response to that. Subsequent to that time, the chairman and I had the opportunity to speak to some of the Rockwell people last week, and from your testimony today, you are indicating that in the purchase of spare parts for the next 4 years, you will be able to keep the production lines open at the subcontractor level, so that when a decision, or if a decision, is made to have the fifth orbiter constructed, those subcontractors would be in place; am I correct?

Mr. BEGGS. Yes.

Mr. MCGRATH. OK; on the question that the chairman of the subcommittee brought up regarding space trans, the fact that Federal Express is now into that company to the tune of about 80 percent, would that make a difference in your either going along with this policy or not?

Mr. BEGGS. I don't know. We haven't seen any new proposals from them since that interest was acquired, so I really can't say. The Federal Express people are a very innovative group and I would expect they will come forward with something that probably

will be different from what we have seen before, but I really don't know.

Mr. MCGRATH. Just to take off one further step, but not to belabor the point, I realize that you have transferred the operation management except for R&D of the remote sensing program to NOAA at this point. You did allude to the fact that they had other options for transferring their new responsibilities with land sensing and also with weather satellites to a private operation. If you were the Secretary of Commerce, would you transfer $1.6 billion worth of infrastructure, hardware, and ground stations to a private or a quasi-private or public organization for $300 million?

Mr. BEGGS. Yes.

Mr. MCGRATH. You would?

Mr. BEGGS. Yes.

Mr. MCGRATH. Could you explain that?

Mr. BEGGS. I should qualify that by saying if a reasonable and well-drawn-up business proposal were placed before me that indicated that it could be operated over the long term with continuity and that they could make a profit from it, I think it would be to the benefit of the United States to transfer any assets for whatever seemed like a reasonable commercial price. It would allow the operation of the system in a way that I think would make it a better possibility that it would become a commercial success over time.

As a consequence, it would grow, would create jobs, and would make available worldwide a more effective direction of the results and the products coming out of the system, and I think that is to the benefit of the United States. Now, I don't believe that such a business proposition has yet been formulated. But, if one were, I think it would be to the benefit of the country.

Mr. MCGRATH. Do you believe at this point in time there is a viable commercial market for land sensing information or METSAT information?

Mr. BEGGS. There is a commercial market, without any question.

Mr. MCGRATH. I said viable commercial market.

Mr. BEGGS. I really can't say. There has been a lot of interest in the private sector in looking at it as a commercial opportunity. There are a lot of questions that need to be answered by anyone who would want to pick it up and operate it as a profitmaking enterprise.

Mr. MCGRATH. I tend to agree with you that there are an awful lot of questions that need to be answered on this subject before it goes forward, and in my estimation that those answers are not readily forthcoming. To have a position paper at this time being formulated or already formulated by the Cabinet Council for the President at the time when a lot of those questions have not been answered, well, then, I think that we are moving a little bit too fast in that direction. Would you agree with that?

Mr. BEGGS. I think that it is not too soon to invite some activity. During the period we have operated this, we have not succeeded in escaping the market to the degree that would sustain the kind of system that we have constructed or would like to operate. Getting some entrepreneurial activity, I think, is very important to the expansion of that market. We have put in a $1.5 billion which is primarily R&D cost over the past several years. The United States

has generally put in that front-end R&D money with the expectation that there would be a commercial opportunity at some point in time, just as there was in the case of communications satellites. I think it is time we persue where we can stir up some interest.

Mr. MCGRATH. I just feel that we have in addition to the $1.5 billion R&D there is a certain infrastructure that has an assessed evaluation which would bring that total price up to about the $3 billion figure including the satellites themselves, the 4 ground-tracking stations and numerous other intrastructure items. I just feel at this point in time we are just moving too fast.

Thank you, sir.

Mr. FUQUA. The Chair yields to Mr. Carney.

Mr. CARNEY. Thank you, Mr. Chairman.

I ask unanimous consent that I may enter a statement into the record immediately following that statement entered by Mr. Winn of Kansas and I ask that members have a certain period of time to submit written questions to Mr. Beggs before the record of this hearing is closed.

Mr. FUQUA. Yes; without objection, we will do that.

Mr. CARNEY. Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Skeen?

Mr. SKEEN. Thank you, Mr. Chairman.

Mr. Beggs, there is a recent release at which you were quoted as referring to the advanced communications technology satellite, an arrangement with private industry that would accrue on a risk-sharing arrangement with industry that would provide significant cost savings to the Government. Would you describe or expand on that?

And, also, how does this program differ or is it like the Japanese 30/20 gigahertz system?

Mr. BEGGS. It is the 30/20 gigahertz part of the spectrum that we are interested in developing. That was opened just a few years ago and the spectrum has become congested. The other parts of the spectrum have been made available to the industries, so this is a very valuable asset which we felt should be exploited. We have been spending significant amounts of money in the R&D area in investigating the 30/20 gigahertz region and developing the various components that would allow us to fly an effective satellite in the 30/20 region. It is similar to the Japanese program in that respect. I might also add the Europeans have an effort going on similarly in the 30/20 region.

We have developed the basic technology to where we think the next step should be to supply and demonstrate that we have a viable, effective system. We would like to enter into a joint program with someone in the industry who would put up money to supply a spacecraft. We would supply some of those components and put together a system that would demonstrate this capability, in the hope that if the demonstration were viable, we could move immediately. This would shorten the time from the R&D phase to the commercialization of the R&D.

Mr. SKEEN. This is all in planning?

Mr. BEGGS. We have talked to several people in the industry and there is a plan to go out and solicit the industry and see what we can get from them.

Mr. SKEEN. Also, I would like to ask what are your plans for the solar optical telescope. I tried to run through the budget here and find it for fiscal year 1984.

Mr. BEGGS. That is in the spacelab payload budget generally. It is $16 million in fiscal year 1984. We will have spent about $10 million through fiscal year 1983.

Mr. SKEEN. That is an indication that you have some very definite plans and priorities as far as the project?

Mr. BEGGS. Yes, sir.

Mr. SKEEN. Thank you very much, Mr. Beggs.

Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Skeen.

Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman.

Mr. Beggs and Dr. Mark, I welcome you before the committee especially since I am a new member to the committee itself.

I would like to first ask about the 80 by 120 addition to the wind tunnel at Ames. As you mentioned, it suffered an accident and you say it is going to be about 2 years before it gets back into operation.

How much is this repair going to cost?

Mr. BEGGS. Somewhere between $10 and $12 million.

Mr. MINETA. And does that go back to the contractor or is that something we——

Mr. BEGGS. No, sir. We won't know until the board has finished its investigation as to whether there is any contractor liability, but, I would have to say that it appears that this most likely will have been in the design.

We had run the tunnel at this speed. It was, I think, 90-odd miles per hour that we were running when it cut loose and threw some pretty large pieces of the vane structure through the blades. Since the blades are laminated wood, all 90 of those laminated blades were pretty much destroyed.

The design had been thought out thoroughly and we thought we had adequate safety margins in it, obviously we did not. We are going back to check all of those calculations now and the Board is looking for either a mistake or an oversight that caused the structure to be flawed so that it would breakdown under test.

That is the bad news. The blades are very special. There is only one producer of that kind of blade in the world and they are in England, and they are an English supplier. The blades require special wood. We have already been in contact with them and are trying to shorten that leadtime to get replacement blades. So, right now our estimate is in the order of 2 years but we are trying to shorten that time because we do have some important test work coming up for that tunnel in about 2 years.

Mr. MINETA. The other thing I would like to commend you about is the numerical aerodynamic simulation. I am really pleased to see $20 million for the first time in that kind of program.

I know that the gentleman to your right has been associated with that program over a long period of time and inasmuch as Ames Research Center is very close to my district we probably have 60 percent of the employees there living in the district although the facility itself is not in my district.

People who work there probably live in the 30th Congressional District. I am really pleased to see this $20 million in this year's budget.

I would like to ask about the shuttle launch delay and the conflict that has been created I guess between the commercial customers, the first spacelab flight and a DOD flight.

I wonder if you could elaborate on this conflict?

Mr. BEGGS. We had, early on, looked at the DOD requirement to fly late this year and we thought we had resolved that satisfactorily allowing us to fly the spacelab as it was intended in late September of this year. The problem that we had with the main engines in January has caused us to revisit that decision. If we cannot get back on schedule by September, then pushing the spacelab further down the year could conceivably impinge on the DOD launch.

I don't know yet whether we have that problem. We are trying very hard to revise our schedules and get back on plan. We don't know yet whether we can fully recover. We have suffered about a 6-week delay, it looks like, maybe a little longer because I really don't know when we are going to get the sixth launch off.

But we have found the source of the problem. We are in the process of fixing it and we hope to get the launch off the first half of March. If we do, then we will go to work to try to shorten the subsequent launches to get back on schedule in time to fly the spacelab in September. But if we don't, we have to push the spacelab further into the year and then we are going to have to revisit the question of that conflict and try to decide when we will be able to fly the spacelab.

If we can't resolve it, we will have to push the spacelab into early 1984. But I am still optimistic that we can solve our scheduling problems and not have a problem of that type.

Mr. MINETA. Well, is it my understanding that the DOD flight is not critical from a schedule standpoint?

Mr. BEGGS. No, that is not my understanding.

Dr. MARK. That is a critical mission.

Mr. MINETA. So you would expect DOD to insist on receiving priority?

Dr. MARK. Yes, I would.

Mr. MINETA. Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Mineta. Mr. Bateman?

Mr. BATEMAN. Mr. Beggs, I listened, with some substantial interest, to your discussion with Mr. McGrath with reference to the commercialization. I think that is the term that I have heard applied to the NOAA satellite activities. The indication has been that a cabinet level committee has made a recommendation that this be done and it awaits the President's approval.

Do you know whether or not it is anticipated to go forward with that, assuming the President's approval, without coming to the Congress or any hearings being conducted by the Congress on the subject?

Mr. BEGGS. I really don't know but I doubt that they would go forward without bringing their decision to you. The committee has recommended that they plan for and try to get a commercial contractor or commercial enterprise to take the system over but that is about as much as I know about it.

Mr. BATEMAN. Is my information correct that 97 percent of the data that is gathered and communicated is communicated to Government agencies for Government programs and purposes?

Mr. BEGGS. I think 97 percent is a little high. One of the large sectors of the market are State and local governments and then the Federal Government itself for that data.

The argument in favor of moving toward commercialization is that commercial enterprise should be able to operate the system more efficiently than we can in the Government and, therefore, the total cost to the Government would come down. That remains to be seen, of course.

Mr. BATEMAN. Well, do we have any experience that would indicate, if it were turned over to eight private or quasi-private concerns who become the sole source of vital information which the Government must have, that the cost to the Government over time is indeed going to be less rather than more?

Mr. BEGGS. It has been true in the communication satellite business in space. The Government buys transponders from the commercial satellite industry and that price has come down very substantially and continues to come down. You can currently buy a transponder for about $2 million a year. Just 5 or 6 years ago it was six or seven times that amount. So, the experience there inspires confidence that if you can truly commercialize, then costs come down.

Mr. BATEMAN. Now, when you say if you can truly commercialize, I am not at all familiar with the transponder market. I don't know whether this is something you deal with in the commodity exchange. I don't think it is.

Is there genuinely a commercial market for transponders and what is the phenomena that has brought down that cost in that particular product, so to speak?

Mr. BEGGS. The steady improvement of the technology and the expansion of the market.

Mr. BATEMAN. The steady improvement in technology was produced primarily by whom?

Mr. BEGGS. By a very well-oiled and workable partnership between the Government program and the industry.

Mr. BATEMAN. Was not much of that technology a spillover of what the Government was already doing?

Mr. BEGGS. Yes, sir. The same thing is true, I might add, in the case of commercial transports and the case of nuclear reactors, the case of a whole host of other products where the Federal Government put in the seed money. It was picked up by commercial enterprises and there has been a continuing partnership in pursuing the technology to ever higher degrees of efficiency. The result, I think, has been very beneficial for the country.

The commercial satellite industry is now a very, very viable and growing commercial enterprise that has created a lot of jobs and has enriched our lives resulting in the Federal Government benefiting by a lot of taxes.

So, if the Government can find an effective way to move the remote sensing business into the private sector, I think, the country will benefit a good deal over the long run.

Mr. BATEMAN. I appreciate your views on the subject. I am not going to say whether I do or don't agree with them at this point. It does offer a very fertile field for further inquiry.

Mr. FUQUA. Thank you, Mr. Bateman.

Mr. Glickman?

Mr. GLICKMAN. I thank my colleague from Texas. I want to welcome my friends, Mr. Beggs and Dr. Mark whom I have seen under difficult circumstances over the years.

I first of all want to compliment the administration for coming to the realization that the first A in NASA is a meaningful one not only from a policy standpoint, but from a fairly reasonable aggregate budget number which is presented to us.

I want to ask you if you feel that the 1984 budget request is faithful to the recently announced White House aeronautical shift. Will it provide for the strong advancement that is necessary for national security and for the continued success of the U.S. Civil Air Force industry?

I guess my concern is, as I look at your budget and analyze it in some degree of depth, I see a lot of what I call systems technology projects—things like prop fan, terminal configured vehicle, laminar flow control that the Congress has strongly supported—conspicuous by their absence. I am also worried that we may see much of the new dollars in the R&T Base, that vast area of undesignated research, going to support military-related projects and not civilian projects.

So I guess the thrust of my question is are you true to your word and working for an improvement of technology in the civil side of the picture?

Mr. BEGGS. I believe we are, Mr. Glickman. I recognize and I am very sensitive to the concern that the committee and the Congress asked that we pursue the civil R&D and I believe that we remain true to that in the R&T Base.

We are sustaining the work that generally applies to any type of aircraft. The work that has gone on over the years in insuring that we have available on the shelf the technology for more advanced, more efficient aircraft of all types including commercial transports, general aviation aircraft, and military aircraft which has served the country well. The program we are proposing here will continue to serve it well.

Let me make a couple of remarks with respect to priorities. We felt in reviewing the programs that numerical aerodynamic simulation was very, very important. It will be, probably, the most important research and technology capability that we have brought on line for many, many years—probably for the last 20 years. Therefore, we put the NAS at a high priority in this budget and will continue that priority into the future. It represents a significant expenditure of our R&D funds in aeronautics.

Second, the Department of Defense is embarked on one of the biggest buildups in aeronautics in their military aircraft in any period in our history. It seems to me that it is incumbent on us to do the necessary research and development to insure that the military has available to it the most modern technology that we can give it.

Third, we looked at the areas where this country had fallen behind. One of those is definitely in the area of helicopters, where much of the development of the technology and the commercialization of the technology has gone abroad. We structured this program to try to move us back into that field very strongly.

Other areas such as the tilt rotor program support important DOD programs such as the JVX and we hope that they will use our tilt rotor technology; therefore, we need a continuation of that work.

That is generally the way we set our priorities.

Now, the budget increase that was given to aeronautics is as large an increase as any of the programs that we have this year, and we felt that within that, we should structure it so as to meet those priorities.

Mr. GLICKMAN. A couple of things. I think that my subcommittee will, in fact, explore the relationship and the depth that the military is spending on new technology. I would suspect that they are spending a lot on new airplanes. I am not sure how much they are spending on research and technology and we are going to look at your budget, but I would commend you for at least recognizing dollar amounts that we have got to meet our competition from the Japanese and West Germans who are not only pulling even, they are moving full-scale ahead on aeronautic research and technology and producing pretty good airplanes as a result of it.

My final question is one that perhaps Mr. Brown may have slightly referred to. I have a growing feeling—there is a growing feeling in America that we are moving toward a militarization of space at a rapid momentum without thinking about how we are going, in terms of how we use space in terms of future warfare. To what extent is NASA looking at this?

I know the DOD has all sorts of plans for the potential use of space in the future, but the Space Act of earlier years talks about the peaceful use of space and I would hope that NASA itself is involved in trying to direct the forces of our dollars in a peaceful way rather than in a military way.

I would just like your comments on that.

Mr. BEGGS. I believe that the budgets we have submitted for at least the last 2 years, which were the first chance that we had to make an impact on the NASA budget, reflect a move in the direction of the civil exploitation. The largest increases that we have made in the budgets in the last few years have been in research and technology, space sciences, and the general areas of R&D in support of peaceful applications.

I would add from my personal view that the DOD also uses space in a peaceful way. The way in which they have exploited space for military use has been primarily a peacekeeping role. The various satellite systems that they employ, the surveillance activities, are all in the direction of arms control and the observation of the guarantees that we get on arms control. So I strongly believe that this Nation is using space for those purposes.

The one aggressive system that has been made operational in the world is the antisatellite system which the Soviets have made operational.

Mr. GLICKMAN. Thank you.

Mr. FUQUA. Thank you, Mr. Glickman.
Mr. McCandless?
Mr. MCCANDLESS. No questions.
Mr. FUQUA. Mr. Nelson?
Mr. NELSON. Thank you, Mr. Chairman.

Mr. Beggs, it is a pleasure to see you again and I am looking forward to our meeting later today on another subject.

Mr. Chairman, I think that my first question would be of a concern from an overall budgetary standpoint. Last year NASA received a 13 percent increase. This year, in the portion relating to space research and technology, it is about a 3.7 percent increase when, in fact, the President's overall budget is 4.9 percent, which he has, by the way, in his budget identified as what they expect as the level of inflation.

Can you tell me why we are falling behind?

Mr. BEGGS. This is the first year that we have received a dividend, if I can use the term, from the shuttle funding. The overall shuttle funding for procurement and operations came down roughly $100 million. The OMB did not suggest that we hand that money back. Quite the contrary. We invested the money in new programs. I would suggest that that does continue the commitment that this administration has.

There is a freeze in the so-called discretionary accounts as well as other accounts in the President's budget and our budget was structured to fit within that freeze. The way in which we went through the negotiations and rationalizations of our budget with the OMB was a tradeoff, not to a specific sum of money, but rather program by program, and we argued it out accordingly. But, there was no intent to cut to a lower level with respect to some 4.5 or 3.8 or whichever number appeared to be the right one. But, we did put more money into the research and technology areas and into the space sciences. We also got the aforementioned new starts which I might add are the first new starts that the agency has had in several years.

Mr. NELSON. In other discretionary programs such as the National Science Foundation they had gotten about an 18-percent increase and, as we explore the intent of this administration and what the priorities are, I was curious as to your answer.

Now, let me ask you, why did you lose your request for a fifth orbiter when you submitted that request to OMB?

Mr. BEGGS. We reviewed very carefully the market forecast to determine where we had been previously and the impact of the competition that we are getting from the Ariane. The fact is the market has not developed as fast as we had previously hoped that it would.

If you draw the line of where the market actually is, on the forecast we gave the committee previously, we are at the lower-end of the range. So, when you look at that market forecast with respect to the capacity of the shuttle, you must conclude that at least for the immediate future it can be well satisfied with the four-orbiter fleet: That is the essence of why we lost the fifth orbiter.

However, as I testified to this committee before, there is a concern by those of us in the Agency as well as folks outside the Agency that we ought to be sure that we back up the systems suffi-

ciently; so that, if we have an accident or have a problem with them, we can repair and maintain the fleet of four. That was the reason that we compromised that issue to buying the structural spares, so that we would have those on the shelf in order to repair or, if necessary, assemble another orbiter if we lost one of them.

Mr. NELSON Is this to say that we concede a certain part of the market to the Ariane?

Mr. BEGGS. No, I am never willing to concede that.

Mr. NELSON. Could that market diminish if we did have a fifth and sixth orbiter?

Mr. BEGGS. Their share of the market will diminish depending on how well we do in making this system operational and in driving the cost down.

If we succeed in doing that, we will eventually, I think, capture the lion's share of the market just as we have in the past captured the lion's share of the commercial transport market by driving the cost down and producing superior aircraft. If we provide a superior service on schedule at a reasonable cost, we will get the lion's share of the market. I am not conceding anything to the Ariane. But, the facts are that they have come in and sold a significant percentage of our market. I say our market because up until the time they came in it was our market and I am concerned about that, but more in light of the necessity to keep this system moving forward and making it operate as it has been advertised to operate.

Eventually, the market may develop to the point that a fifth orbiter is required. If it expands that market as the President said in his policy statement, we retain the option to produce another orbiter. But right now, if you look at the market forecast, the demand for that amount of capacity is not there. I regret to say that, but that is the way it came out.

Mr. NELSON. Would you have an objection to the Congress providing for a fifth orbiter in the 1984 budget?

Mr. BEGGS. That is a "gotcha." Well, I can't come up here and say I can accept it.

Mr. NELSON. But you can't say you would reject it either?

Mr. BEGGS. No.

Mr. FUQUA. Thank you, Mr. Nelson.

Mr. Durbin.

Mr. DURBIN. Thank you, Mr. Chairman.

Mr. Beggs, I appreciate your presentation today. I would like to ask you to comment on one very small portion of your budget proposal here, but one that is of interest to me and that is in the area of technology utilization. It appears that there is a rather substantial cut in the amount that is being projected to be spent by NASA in fiscal year 1984 on technology utilization.

I think we would all share the belief that we do need to make every conceivable effort to share the technology that is accumulated by your agency and other agencies of Government and it would appear that this cutback would constrict the traffic of this information to Government agencies, the education sector, private business and other areas where it really might add to a practical secondary usage.

Could you comment on why there is going to be this kind of cutback or at least you are proposing it for 1984?

Mr. BEGGS. We proposed a similar cutback last year and the committee added to that amount. The argument is that if the information is valuable, then the recipients ought to pay for it. That is the classical argument. It always goes on with the dissemination of valuable products and services that the users ought to pay which is pretty much the gist of the argument.

I personally share your views that we must continue to disseminate that information. It has proven valuable to us. The information goes out to the schools, industry, and the general public. This, of course, is something that is, I believe, a proper role for this Agency to insure that its information is disseminated widely; but, the argument again is that the users should pay for that service which is why the budget was cut to $4 million.

Mr. FUQUA. Thank you, Mr. Durbin.

Mr. Walker.

Mr. WALKER. I thank the chairman.

Mr. Beggs, you stated that you have budgeted money for spares in fiscal year 1984. Can you tell us what structural spares you are talking about and how much money NASA has for spares in 1983 and in 1984?

Mr. BEGGS. The budgeted amount is $100 million in fiscal year 1984 for the structural spares. But actually, we would be spending in the area of $300 million for all the orbiter spares that we will be buying in fiscal year 1984. We are just now getting into the period when we are buying spares heavily. Up until now we have not spared the system to the degree that it needs to be spared for continuous operation.

As a matter of fact, because we fell behind in the construction of the orbiters, we were actually not able to get the amount of production that would allow us to spare adequately. So, we have been reduced to the practice of cannibalizing subsequent units to get our spares. We have been using production units for our spares when we need them and that is a very bad practice. I do not condone it. But, we are now sparing at a fairly high rate and we will continue to do that over the next several years.

With respect to the specific structural spares we can buy, I can submit that for the record, as it is a long list.

[The information follows:]

NASA is planning to spend approximately $170 million on spares in 1983, and about $275 million on spares in 1984. Of these amounts, orbiter structural spares account for $20 million in 1983, and $100 million in 1984, totalling $420 million in run out.

A specific parts list has not yet been developed; however, both major structural items and components will be procured. The selected structural parts are those most likely to be damaged in handling incidents or landing accidents (rudder, elevons, speed brake, landing gear, landing gear doors). These parts will be totally finished and ready for installation on the orbiter when needed. The major structural assemblies are the wings, aft thrust structure engine compartment, crew module including the nose and cockpit, and mid and aft fuselage sections, payload doors, vertical tail and the Orbit Maneuvering System pods. The wings, engine compartment and midfuselage will be delivered in fiscal year 1986, the other parts and assemblies will be delivered in fiscal year 1984, and fiscal year 1985. All the major structural assemblies will be completed only up to the point where they are ready for installation of thermal protection system, plumbing, wire harnesses, and major electrical propulsion and hydraulic components.

Mr. WALKER. That will be fine. Is your statement true of the spare engine that you are now using? You say that you are using production units, the spare unit that you are going to use——

Mr. BEGGS. No. We bought an extra engine for these first two orbiters.

Mr. WALKER. So that will have no impact?

Mr. BEGGS. No, sir. That does not have an impact. We are asking in this budget for an additional spare engine. As we move forward, we will see just how well these engines operate over time and whether we are going to get the number of repeat operations projected. We think we will.

As you know, the engines were scheduled to fly 10 times between major overhauls and we think we can increase that usage. But, we have had problems with the main engine and we are still learning a lot about them. We had a very sobering lesson here in January when we discovered we had a leak, we also discovered that it was very difficult to test the system to find a leak. Hydrogen is a very slippery gas and it is difficult to trace. So, we are going to have to review that system to make sure that we have adequate test procedures to cope with any eventualities such as occurred.

Mr. WALKER. Can you give us some idea as to how long it would take to change out a structural spare?

Mr. BEGGS. It really depends on whether you are talking about something in the primary structure of the orbiter itself or in things like the body flap or the tail. If we had to replace the body, it would probably take 1 year or more.

Mr. WALKER. But that would have considerable impact on your flight manifest?

Mr. BEGGS. We expect that we will be able to operate the system 8 flights a year per orbiter when we get up to full operation which would give us the theoretical capacity to support 24 flights with 3 vehicles. Now, you can't do that continuously because you do have to lay them up from time to time for unscheduled maintenance, overhaul, and for modifications as we learn more about them. This is true of any machine that flies. The first transports, for example. The airlines build in a certain period where they can lay the airplanes up and fix them, overhaul them, and do minor mods on them because you are always modifying a flying machine.

So we think that with 4 orbiters we can sustain a flight rate up to that 24 a year which is what we projected and that looks like it will satisfy the market demand at least as we see it right now. And as I said in response to Mr. Nelson's question, if the market expands more than we see right now then we will have to go back and revisit the necessity of another orbiter.

Mr. WALKER. In other words, you can maintain that kind of a flight manifest schedule even if you had a changeout that was taking you 1 year?

Mr. BEGGS. Even if we had to lay one up for 1 year; yes, sir.

Mr. WALKER. Who is conducting your spares analysis study?

Mr. BEGGS. We are, with our prime contractors—Rockwell, Martin, and Thiokol.

Mr. WALKER. Would it be cheaper to procure the spares from component subcontractors rather than getting it from Rockwell?

Mr. BEGGS. It conceivably would be cheaper and we are taking a hard look at breaking out some of those spares. Up until now, we haven't felt that that was a good policy while we were heavily in the production process and were behind in schedule because that, of necessity, puts perturbation in the suppliers schedules and we didn't want to do that. But, we are looking very hard at breaking out some of the main items to see whether we can buy them direct.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Walker.

Mr. Harkin.

Mr. HARKIN. Thank you, Mr. Chairman.

Mr. Beggs, I don't want to belabor the point but did anyone cover the space telescope with you before I came in? Was that discussed at length?

Mr. BEGGS. We discussed it; yes, sir.

Mr. HARKIN. I just wanted to know what launch date you see for it. You said you had some problems with it?

Mr. BEGGS. We have problems in the electronic and the guidance pointing system of the telescope. We don't yet know how serious those problems are. We do know that they are going to impact the schedule. I don't know how much they are going to impact the schedule.

I will personally, be visiting the prime contractor to review the program in detail to try to assess the situation there later this month. Once I have completed that review, I am going out to Lockheed, the other major contractor, to review the situation there. After that I hope to have a fix on where we stand with respect to schedule and cost. I think that probably means that it we will be sometime in March before we have a complete understanding of how serious our problems are.

Mr. HARKIN. Prior to this what were you looking at as a launch time?

Mr. BEGGS. The first half of 1985 or possibly midyear.

Mr. HARKIN. It is still possible you can meet that?

Mr. BEGGS. It is possible; but, I have got to say that from my preliminary look at this, we have a slip. I just don't know how much of a slip. It may be a matter of a few months or it may be as much as 6 months or more.

Mr. HARKIN. You, I am sure, will keep the subcommittee informed.

Mr. BEGGS. Yes, sir.

Mr. HARKIN. I also just wanted to say that I also share Mr. Glickman's interest in, and concern about, the possible militarization of NASA in the future.

I hope that we can have further dialog on that as we go along.

Mr. BEGGS. Surely.

Mr. HARKIN. Thank you.

Mr. Beggs, one of the things I am very pleased that Mr. Glickman mentioned about the A in NASA and you mentioned about the numerical aerodynamic simulator which I think is a very excellent move in that direction.

What is the timeframe for that?

Mr. BEGGS. I would like to have Dr. Mark answer that. That is very near and dear to his heart and I think we ought to let him discuss that.

Dr. MARK. We are looking toward having an advanced computer system which will be part of the aerodynamic simulator in 1986 and 1987.

Mr. FUQUA. Is it operational?

Dr. MARK. Yes, sir. In the meantime, we will procure the best computers that we can get on a lease basis to serve as the centerpiece of this computer and then build the peripheral network incrementally around it.

As Mr. Mineta knows, this concept grew from a computer center that we developed at the Ames Research Center in the 1970's. This is really the next generation of that facility. It will be put in the same building that we had for the Illiac. I think it is extremely important not only for aeronautics, but also, and this is something that this committee is concerned about, and that is for driving the technology of other computers. This not only will allow us to make better airplanes in the end, but also will create better computers. So, that is a twofold advance.

Mr. FUQUA. That was my next question. How will that compare to the existing super-computers and particularly the Japanese aspirations in the same timeframe?

Dr. MARK. We have very conscientiously put the timeframe of this computer in a period to create good competition. We are really talking about two different technologies here. We are trying to work the contractor community in such a way that we have a choice of either getting the speed by trying to improve the hardware as best we can or by getting it through being clever with the way the hardware is put together. In a way, the two contractors that we have competing, represent those viewpoints.

In the case of the Japanese, they are going to rely on component and hardware improvements more than on the software or the architecture because that is where they are ahead or that is where they think they are ahead.

My own feeling is that if we actally make this system work the way we think it will work, we are going to have a good edge on them.

Mr. FUQUA. Who are the two contractors who are competing?

Dr. MARK. Cray Research and CDC.

Mr. FUQUA. Mr. Beggs, I saw a quote recently from the Under Secretary of the Air Force in the latter part of last month where he stated that the Air Force was in support of the fifth orbiter, of course, providing it did not come out of their funding. Are you aware if they still support the fifth orbiter?

Mr. BEGGS. They pretty much concurred in the decision that was made with respect to maintaining the four-orbiter fleet and providing an enhanced spares budget. Their position has been as long as they are adequately serviced, they don't care how many vehicles we fly. As I said, one of the reasons that our market decreased in the near term is the fact that a number of the DOD missions have fallen out. They have not maintained a requirement for as many missions as they previously had suggested.

My personal view on that is that over time, when they find what they can fly and what they can do, that they will be flying more and demanding more missions; but right now, in the next 4 or 5 years their demand is down. So, we can adequately service them with a four orbiter fleet, but with very little risk.

Mr. FUQUA. In your review of the difficulties with the space telescope, are you going to review the management of that program at NASA as well as the contractor?

Mr. BEGGS. I have already begun that and I have discussed the management problems with the contractor. Perkin-Elmer is in the process of making some management changes now. I am going to look very hard at the way that NASA has run this program and whether we have an adequate management structure. The way we have set this up is difficult. We have contracted directly with several associate contractors; and, as a consequence of that, it has been incumbent on NASA to insure that the necessary integration and the necessary systems aspects are adequately covered with each of these associates. We are going to look hard to see if we have done that in a proper way. I believe that we have though, Mr. Chairman.

I don't want to leave you with the impression that I have any strong feeling that we have not done our job. I think we have. We are going to look for deficiencies in the way we have run this or if there are deficiencies in either the manpower or resources, we will fix it. But, what we have run into here is both technical and managerial. It is very easy to blame your problems on the management. You can shake up the management and think you have fixed something; but, actually, you have only papered it over. I think we have got to get down into details to find out how serious our technical problem is. We are trying to do something very difficult here which has never been done before.

Mr. FUQUA. My main concern is the fact that when these things develop usually they are in a monumental problem before you find out about it or before we find out about it. And my concern is that we have a better triggering device to trigger those problems before they get monumental.

Mr. BEGGS. One of the reasons that this whole situation developed was that we all sensed there was something wrong. I held a review of this program late last year here in Washington, and I wasn't satisfied with it. I told the folks down at the Marshall Space Flight Center to go back and revisit it. They have been doing that. As a consequence of the passage of time as well the problems surfaced. But, they have been looking hard, and in January they announced that we have a problem. Within 2 months the problem came to light which indicates that maybe we had some effect.

I am a little bit embarrassed about this one because having reassured the Congress that it was going all right as recently as October and then coming back 4 months later and saying we have got a serious problem on our hands, it certainly does raise serious questions as to the management of the program, and I don't like that.

I think generally the Agency has done a good job of staying on top of its problems, and I don't know that we haven't been on top of these as well. We have talked a number of times with the contractors expressing concerns in various areas. In most cases they

have taken action and done what we asked them to do. But this one is something that apparently has been papered over, and now it is obvious that it has got to be addressed.

Mr. FUQUA. Well, it is a little bit of concern to us because I recall when it was first proposed, the committee did not authorize it that year. We sent NASA back to the drawing boards to better define the program, review the technical considerations that were involved. And we thought also by doing that we were going to make it a better program. It was going to really come in within cost and on time, so this is of great concern that these problems have developed.

Mr. McCandless.

Mr. MCCANDLESS. Mr. Chairman, although at the time that I was called upon I did not have any statement, and I do not plan to ask Mr. Beggs any questions. I am impressed with the candidness with which Mr. Beggs has responded to the questions of the Chair, and I would like to leave that thought with him as he leaves the room and proceeds home.

Mr. FUQUA. Mr. Volkmer?

Mr. VOLKMER. Yes, sir, I would like to ask a few questions. I am sorry I had to step out. I had some other people come in.

I don't know if you have been over some of the planetary programs. Have you been over those?

Mr. BEGGS. No, sir.

Mr. VOLKMER. Can you tell us where we are as far as Galileo?

Mr. BEGGS. Galileo still looks good. The program still remains on schedule and within budget, and we are proceeding to the 1986 launch date. As you know, during this past year when the Congress told us to return to the Centaur we had to move the Galileo program back onto the Centaur. That was a flight perturbation, but the actual result of that will be a better mission because we have got even more energy in that stage and we can get there sooner and stay there longer. That has been successfully integrated into the program, and we are well underway.

I think that pretty well describes it. There are no significant problems at this time that I know of.

Mr. VOLKMER. We presently have existing spacecraft out there which we are updating data from; in other words, the Pioneers and Voyagers. Do we have sufficient money in this budget to continue the tracking and information gathering?

Mr. BEGGS. Yes, sir. This budget will support the Pioneers, the Voyagers, and the other probes that are still alive. The Voyager II, which is on its way to Uranus, is still alive and well, and we are prepared to support that encounter in 1986; 1986 will be the banner year.

Mr. VOLKMER. It sounds like it. And the new Venus probe, I understand we are actually going to save some money.

Mr. BEGGS. We were told to go back and look at a lower cost mission. We did. We think we have a very good mission at roughly half the cost of the VOIR and we will get most of the science that we had on the VOIR. We won't have quite the resolution from the imaging radar that we had on VOIR, but, we are going to have a very good mission. We think we will be able to bring it in for

around $350 million, which is approximately half what it costs for the VOIR and the scientists are very pleased with it.

Mr. VOLKMER. I notice that the planetary research budget has a reduction, not quite $5 million.

The research, not operations or tracking. What is the impact of these cutbacks in research on planetary exploration will not be spent in 1983?

Mr. BEGGS. Will carry over in 1984, yes, sir. Is that what you said? That is not exactly what they said. If we could take the two accounts, the research and analysis and the mission operations and data analysis [MO&DA] which tends to be the kinds of money that fund the ongoing university and other principal investigators that we have working with us, that those two are at a stable level.

Mr. VOLKMER. Maybe we can carry this on a little further when we have our authorization hearings.

Mr. BEGGS. The MO&DA increases from $38 million to $43 million and the R&D decreases $50 million to $45 million. If you add the two accounts, it is about the same level.

Mr. VOLKMER. In other words, they will wash out if you add the two together?

Mr. BEGGS. Yes, sir.

Mr. FUQUA. Mr. Nelson.

Mr. NELSON. Thank you, Mr. Chairman.

Upper atmosphere research satellite. That has been on the books for years, about $40 million has been expended. Is it going to be go or no go, and if so, whichever your answer is, why?

Mr. BEGGS. That is the next new start that we want, and I hope we can wedge it in in the next year.

Mr. NELSON. What, in fiscal year 1985?

Mr. BEGGS. Yes. The money that you mention has been spent on instruments, and that work will continue in fiscal year 1984, just as it is going on in fiscal year 1983. We will continue to develop those instruments so that we are prepared to put them onboard a satellite when we get going on that new start. The money that we are spending is directed toward a useful product. When and if we go forward with the program.

Mr. NELSON. Are you satisifed that the Department of Defense is picking up its fair share of the load?

Mr. BEGGS. Yes, I am. I went to the Secretary of the Air Force—not quite 1 year ago, I think it was in June of last year, to suggested two things to him. One, that we break the previous agreement we had on the price of the shuttle and raise that from $12 million to $16 million, which was a 33-percent increase. The numbers I quote are all 1975 dollars, so you have to escalate them to current dollars. The Air Force felt that they had a binding agreement at that price.

Second, that we raise the price for 1986 through 1988 to $29.8 million. So that it would be in consonance with the price that we were charging our commercial customers, which is $38 million. The difference between the two is the previously agreed to exchange of operations cost—what they pay for at Vandenberg and what we pay for at Kennedy and Johnson and the $4 million that we put into the $38 million as a contingency amount. So, it is a wash of

those two accounts. That makes their price come out around $30 million. They swallowed hard, but they did swallow it.

Secretary Orr agreed to the basic price, I believe, in August of last year. But we didn't sign the memorandum of understanding [MOU] at that time because they had a number of other issues that we wanted to resolve in the details of how we would operate with each other, which is fair. We have been negotiating those details ever since, and we have just signed the agreement. But the basic pricing agreement was agreed to in late summer of last year.

My view is that they are paying their share of the costs. Those prices will result in about a billion dollar increase over the time period we are talking about here. It is an equitable arrangement with respect to the price we are charging to commercial customers. If you charge them more, they will definitely be subsidizing the other customers, which I don't think would be fair, either. They have, of course, continued with their commitment to finish off the Vandenberg launch facility in spite of the fact that they have had to absorb higher costs out there. So they have had a significant increase in the budget, part of which, although certainly not all, has to be attributed to the fact that we have had changes in the shuttle program as we have gone along and learned more about it. That has cost them more money. They have bellied-up to that and paid the price. I think they have carried out their end of the bargain, which was made way back in the mid-1970's; and, I think, we have likewise carried out our end of the bargain, except for the fact that we reneged on the first 3-year price. We raised that from $12 million to $16 million in 1975 dollars, and they rightfully called us to account for that but they did ultimately agree to pay the higher price.

I think they have been very forthcoming and I would urge on the committee that we allow that to operate.

Mr. NELSON. You know the problem we have had here, some of the movement that we have had, so I appreciate that information.

The CHAIRMAN. Mr. Beggs, the Air Force was supposed to provide some money for spares in 1983. What happened to that money?

[The information follows:]

The Department of Defense has no money explicitly identified for orbiter spares. Under both the prior and the recently renegotiated agreements between NASA and the DOD for Shuttle flight charge reimbursement, orbitor spares are a NASA funding responsibility and flight replacement spares are an element of cost included in the reimbursable charge per flight.

Mr. BEGGS. I am going to have to review the records. Part of the money that they had in their hand was spent, I believe, for the Vandenberg overrun that they ran into this past year; but, I believe they still have some money available to put into spares. I think that decision will be made after the sixth flight. But, I would like to come back to you for the record on the details of that because I am hazy on it.

Mr. FUQUA. It was my understanding that there was an agreement that they would provide money for spares, not necessarily——

Mr. BEGGS. Oh, yes, over time they will provide money for spares. They are required to provide spares support at Vandenberg,

and they will do that. But the thing we were referring to last year was some money that they had identified that they had left over from not procuring some follow-on Titans, that they were going to put immediately into spares, and I am just hazy on where that stands right now. But I do know they spent some of that money for the overrun at Vandenberg.

Mr. FUQUA. General Abrahamson can address that when he testifies before the subcommittee. Do you have any idea of what the launch date might be for STS–6 now?

Mr. BEGGS. We are trying for the first half of March, and I think we will launch in the first half of March.

Mr. FUQUA. That will probably be nearer the middle?

Mr. BEGGS. Well, we are all pushing to move it as close to the first of the month as we can. If we could get it launched in the first week or in the first 10 days, it would be very helpful. I shouldn't be too optimistic here, because we still have to pull the engine. We are just starting to do that, and if we encounter no problems there and it goes smoothly from here on in installing the spare and in getting the system back on the count, then we ought to be in pretty good shape and we will be able to set a date.

I hope it can be as early in March as we can, but we may be close to the 15th.

Mr. FUQUA. You don't anticipate another FRF, then?

Mr. BEGGS. No, sir, I don't. We haven't reexamined that in detail as yet. We will have to get together to review all the data. I don't think that Dr. Mark has as yet looked at the details of the data we have from what we found in this engine and the repairs that will be made now. As soon as we have that data, we will have to make a judgment as to whether we want another FRF, but right now I don't think we will.

Mr. FUQUA. It would take about 1 week to change that engine?

Mr. BEGGS. About 1 week, yes.

Mr. WALKER. Mr. Chairman.

Mr. FUQUA. Mr. Walker.

Mr. WALKER. Mr. Beggs, in answering the question about Landsat commercialization, you compared it to commercialization in the telecommunications satellite field. I share an enthusiasm for commercialization, and I think that example is a good one of what has been achieved. I am a little concerned about the analogy because in the case of telecommunications you had a fairly strong commercial infrastructure on the ground prior to launching the satellite. In the case of Landsat I do not know that we have established at this point that there is any ongoing business in place for Landsat information. Would you acknowledge that there may be some significant difference between the two from that standpoint that would have some bearing on future commercialization?

Mr. BEGGS. Yes, sir, there is a very great difference between the Landsat, the market for Landsat data, and the communications satellite business. When I drew that analogy, I believe I drew it in the context of turning over a significant amount of Government R&D to a private enterprise, which I happen to believe is a great idea. The Government invests at the front end and when the technology reaches the point where it should be turned over, I think, it ought

to be written off and turned over for nothing, because what you want to have at that point is as quick a development of the research and technology into commercial reality as you can. There is a very great difference between the market for Landsat data and communications services, though.

As you pointed out, the communications market was there. Although in that time period, there were numerous reports and statements that communications satellites would never be cost-competitive with land lines and microwave. I can go back and read you chapter and verse on that. We all know the history of it. It developed very rapidly, the costs came down, and it was a great success. My feeling is that what is needed in the Landsat area is some entrepreneurial activity, which I define as going out and creating a market. It does have that potential if somebody can grab ahold of it and work it hard, that a market can be developed for the data. We found a lot of very useful applications of the data so far, but certainly we have not explored it in as great a detail as possible.

Basically, the Government does not try to market things. We do not advertise, nor do we really have a sales organization. What we do is set up shops to offer the technology for anybody that wants to come up to the desk and buy it or take it as the case may be. And I think that there is an opportunity here, whether it is a real opportunity or not—someone is going to have to decide that, and whether he wants to put his money or his stockholders' money into developing that market and to make a judgment as to whether he can make a success out of it. As I said earlier, if someone came forward with a viable business proposition for the Government and suggested that they can run the program more efficiently and create a large market for the service, then I think we ought to take them up on it.

Mr. WALKER. In line with that, one general question, and then I am finished. It seems to me that in the past NASA was best known as an innovative kind of agency that was really in the process of greatly expanding the frontiers of knowledge and as a result really fostered tremendous technological innovations. We realize that you have been up against budget crunches and there has been a need toward getting the shuttle operational, but as we move to that, do you see the Agency assuming a more innovative technological forcing role than it has had in the recent past?

Mr. BEGGS. NASA is 25 years old. When you look back over those 25 years, there has been an enormous creative surge that has come out of the program. It has benefited not only the direct industry, the aerospace industry and the spinoffs from aerospace, things like the communications satellites, but it has also benefited a lot of other industries. Dr. Mark alluded to one in the computer science, that we pushed that technology through our program. One can point to medical electronics and solid state electronics and a lot of other areas where we have pushed the technology and moved the industry in a more rapid and more competitive way. I think that in the coming decade, when the shuttle is fully operational, we can get back and put more money into the more typical or more basic kinds of things that NASA does in research and technology. I think the opportunities in the next 25 years are, if anything, much greater than they were in the past 25 years.

I gave a speech on this subject as to what has happened to the Agency. I happen to think the Agency has done quite well. If you look at the last 10 years and what the Agency has been able to do with constrained resources it is very impressive. We have developed the shuttle and we have kept the other programs alive, not to the degree that much of our constituency would like, but we have done good work and the results have been impressive. In 1972 we had a budget of $3.3 to $3.4 billion. In 1982 terms if we ran that out, the budget at $3.3 or $3.4 billion would represent what would be about $7.5 to $8 billion in real year dollars. Instead we had $6 billion so we lost 20 to 25 percent of our purchasing power in 10 years, and that hurts in terms of what you can do. If we had had that extra $2 billion in 1982, I feel confident that we could have done all of the things that we have previously done in the other program areas. But we did not, so we had to tailor the program accordingly. The argument is that the shuttle kept pulling funds from those programs, and that is true. But, you also have to recognize that in the real budget, the real amount of resources available was coming down, and coming down significantly. When you lose more than 20 percent of your purchasing power, it is clear that you cannot do everything that you previously did.

To put it in other terms, in 1972 I think that NASA's percentage of the Federal budget was between 1 and 1.5 percent and in 1982 it was eight-tenths of 1 percent. I might also add that that is true of R&D generally in this country. If you go back to the 1960's in this country, public and private expenditures on research and development were running at about 3 percent of the gross national product. The Government R&D was about 60 percent of that expenditure and the private was about 40 percent. Today, it is about 50–50, but it is just a little over 2 percent of the GNP.

If you think about that, that may explain why we have lost our competitiveness in a number of areas, because the real driver of productivity and the competitive posture of a country is based more on technology than it is any other aspect. So, it is disturbing. But, I think that if you look at the performance in an objective way over the last 10 years, that you would have to agree that the Agency has done a pretty good job in keeping all of its programs alive and reasonably healthy. It has been about 5 years since we have had a new start, except for things like Explorers—Hans reminded me we had the Gamma Ray Observatory [GRO] about 3 years ago. But generally, they are few and far between. This year we have got an agreement to move ahead on several new things. I have not talked about the other area that we have enhanced this year, that of construction of facilities, which we think is extraordinarily important.

As I have mentioned several times to the committee in the past, we have been running increasingly into unplanned maintenance, unscheduled maintenance, and the backlog in many of our facilities has been growing, which indicates that our facilities are aging. It is not being maintained and modernized as it should have been in order to handle the demands upon it. And we asked for and received this year a very significant enhancement of that, and I think that is a very important part of this budget. It is an almost 50-percent increase in the facilities budget.

I do not know whether I have answered your question or not.

Mr. WALKER. As I said, it was a general question, and I think you gave a general answer. Thank you.

Thank you, Mr. Chairman.

Mr. FUQUA. Mr. Volkmer.

Mr. VOLKMER. Just a type of accounting question. When you receive funds either from the Air Force or private corporations for utilization of the shuttle, what happens to those?

Mr. BEGGS. We keep them and use them in the program.

Mr. VOLKMER. Where do they show up in the budget as income?

Mr. BEGGS. Where do the reimbursements show up?

Mr. VOLKMER. And reflecting them through the budget totals.

Mr. BEGGS. They do not show up in the direct budget, but they do show up in the summary section budget—there is a special summary there for reimbursables.

Mr. VOLKMER. In other words, I can go through here and find how much you are actually going to be reimbursed in fiscal year 1984 for the various operations; is that correct?

Mr. NEWMAN. If you are looking at the overall program and finance schedules up near the front of the book, yes, sir. You can see the amount of reimbursement in there.

Mr. VOLKMER. So, what you are asking us then in the total for the operations like of the shuttle is over and above what you need from reimbursements, then; is that correct?

Mr. NEWMAN. That is correct. In the shuttle operations area——

Mr. VOLKMER. In other words, in the shuttle operation in the budget you would show so much of what I would call general revenue or whatever, and so much for appropriations, and so much for reimbursements?

Mr. NEWMAN. Yes, sir, there is about $150 million in fiscal year 1983, and $260 million in fiscal year 1984, for shuttle operations over and above the amount that you see in our fiscal year 1984 budget request, and that is from customers.

Mr. NELSON. Including the Air Force?

Mr. NEWMAN. Yes.

Mr. BEGGS. Those amounts have not been large in the past. They, of course, will build up rather rapidly now as we start to fly the shuttle. In 1982, they were $50-odd million and less in previous years. It goes up to well over a billion dollars as you get out into the mid and late 1980's.

Mr. VOLKMER. Thank you very much.

Mr. FUQUA. Thank you very much, Mr. Beggs. We appreciate you being here today, you and Dr. Mark, and we look forward to a very successful year in space activities.

Mr. BEGGS. Thank you, Mr. Chairman.

Mr. FUQUA. The committee is adjourned until 10:30 Tuesday morning, when we will receive testimony from the Secretary of Energy, Mr. Hodel.

[Whereupon, at 4:30 p.m., the committee was recessed, to reconvene at 10:30 a.m., Tuesday, February 8, 1983.]

1984 NASA AUTHORIZATION

TUESDAY, FEBRUARY 8, 1983

HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE AND TECHNOLOGY, SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS, SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS,

Washington, D.C.

The subcommittees met, pursuant to notice, at 2:15 p.m., in room 2318, Rayburn House Office Building, Hon. Harold L. Volkmer (chairman of the subcommittee) presiding.

Present: Representatives Volkmer, Nelson, Dymally, MacKay, Torricelli, Lujan, Carney, Lowery, Chandler, Bateman, Walker, Boehlert, and McCandless.

[The opening statements of Mr. Glickman and Mr. Carney follow:]

STATEMENT OF HON. DAN GLICKMAN

The Subcommittee on Transportation, Aviation and Materials is pleased to join with the Subcommittee on Space Science and Applications for the purpose of receiving testimony on the fiscal year 1984 NASA Authorization request. Today we have several NASA witnesses who will be testifying on a variety of issue involving construction of facilities and operation of NASA centers throughout the country.

STATEMENT OF HON. WILLIAM CARNEY

Thank you, Mr. Chairman. I, too, want to welcome our witnesses today and look forward to hearing their testimony on NASA's Facilities and Research and Program Management budgets for 1984.

I am especially gratified to see that this year the aeronautics centers are not being asked to reduce their staffs again.

The erosion of the technical staff has had a serious impact on NASA's in-house capability. If this country is to maintain its position of leadership in aeronautics, it's important that NASA have a strong in-house research capability. This requires modern facilities and equipment, but even more important—it is absolutely essential that NASA have the innovative researchers necessary to conduct the basic research which is its first responsibility. This requires a continual infusion of new talent. Perhaps this year NASA will be able to recruit some of the young innovative researchers it needs.

Thank you.

Mr. VOLKMER. The Subcommittee on Space Science and Applications is pleased to join with the Subcommittee on Transportation, Aviation and Materials for today's hearing. We look forward to close cooperation between the two subcommittees as we review the NASA fiscal year 1984 budget request. I would like to welcome our witnesses today and look forward to your testimony. Our witnesses are C. Thomas Newman, Comptroller for NASA; Billie J. McGarvey, Director of Facilities; Walter B. Olstad, Associate Administra-

tor for Management; and S. Neil Hosenball, General Counsel. Mr. Newman, you may begin your statement. Your full statement will be made a part of the record.

[A biographical sketch of Mr. Newman follows:]

CHARLES T. NEWMAN

Mr. Newman was appointed Comptroller in November 1981.

Mr. Newman served as Deputy Comptroller from 1977–1981. He joined NASA in 1963 and served in a key capacity as Chief of Apollo Resources during the mid-sixties. From 1968 to January 1977, he served as Deputy Director and Director of the Office of Resources Analysis.

Before joining NASA, Mr. Newman served with the Department of the Navy, the Atomic Energy Commission, and the Office of the Secretary of Defense.

In 1969, he received the NASA Exceptional Service medal and in 1976, was one of the initial recipients of the NASA Outstanding Leadership Medal, and in 1981 received a second Outstanding Leadership Medal. Also, in 1981 Mr. Newman was awarded the Rank of Meritorious Executive by the President of the United States.

Mr. Newman earned a Bachelor of Arts Degree in Government at Beloit College, Wisconsin, in 1951, and later a Masters Degree in Politcal Science at the University of Illinois at Urbana.

STATEMENT OF C. THOMAS NEWMAN, COMPTROLLER, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY THOMAS CAMPBELL, DEPUTY COMPTROLLER, NASA

Mr. NEWMAN. I plan to give you a compact summary of the budget, and since I am appearing this year before the program associate administrators, I will give you a brief summary of the program content as I go. We have given you a handout package, and I plan to cover the first 16 pages of that package. The remainder of the material is additional reference material which you may wish to insert in the record. On page 1, we are showing the total budget request. We are requesting $7,106.5 million in budget authority. The outlays that go with that are $6,981 million. Our request for fiscal year 1984 is up $267 million, or about 4 percent above the level for fiscal year 1983. You can see that the requirement for space transportation systems is down about $100 million. We have been able to apply some increase in the areas of space science and applications, in aeronautical research and technology, and in the space research and technology. These amounts are the fiscal year 1984 appropriations that we are requesting for NASA.

On page 2, I have summarized the planned flight activity. As you know, we have completed the shuttle development flights, and the first operational flight was conducted last fall. Our schedule calls for 4 more operational flights in 1983, and 8 to 9 flights in fiscal year 1984, building up to a rate of 24 flights by the late 1980's. The first spacelab flight is scheduled for late 1983, with a second flight in 1984 and two more flights in 1985, and then, of course, they continue on. The first upper stages have been launched. They were launched on the STS–5 mission and were the small spinning solid upper stages. The first flight of the inertial upper stage will be on the next mission, STS–6, and will be used to propel the tracking and data relay system satellite into its geostationary orbit. The first Centaur flights from the shuttle will be in 1986 for the Galileo and International Solar Polar missions. You may be aware that we have just launched the infrared astronomical satellite; and, at last report, that satellite, which is a joint project with the Dutch and

the British, is doing very well. We will launch the first U.S. search and rescue transponder on the NOAA spacecraft about the end of March of this year. I have shown on this schedule, the space telescope launch in 1985. As Mr. Beggs said last Thursday, we may encounter some delay in launching that mission. There are a number of other important missions in the 1984 budget. I have already mentioned the International Solar Polar mission and the Galileo mission in 1986. We have the gamma ray observatory, the Venus radar mapper mission, and the advanced communication technology satellite scheduled for launch in 1988. The first tracking and data relay system satellite will be launched on the next shuttle mission. Another one will be launched this year and the third one will be launched in 1984. That will establish a system of two operating satellites on-orbit and one on-orbit spare. Another mission shown is the Earth radiation budget experiment [ERBE]. The first element to be launched will be a set of instruments on the NOAA spacecraft into polar orbit, followed closely by a shuttle-launched ERBE spacecraft into a low-inclination orbit, so the two can gather data simultaneously. We have also shown on the chart the solar maximum mission repair retrieval mission scheduled for late 1984. That is a quick summary of the major space flight elements of the program.

On page 3, I have summarized the space transportation systems program. A key element of that program is the completion of the four-orbiter fleet. We have the continued development of the filament-wound case for the solid rocket boosters to provide for performance augmentation. We, of course, are continuing development of the Centaur upper stage for use in shuttle, as a joint project with the Air Force. We will initiate the spacelab flights, and we also are providing for procurement of the second set of flight hardware from the European Space Agency. The tethered satellite is a new project that is initiated in the 1984 plan. That is a small satellite on a long wire attached to the shuttle, and it is a joint effort with the Italians. I mentioned the buildup of the shuttle flight rate to 8 or 9 missions. We also plan 11 missions on expendable launch vehicles in fiscal year 1984. Compared to fiscal year 1983, the funding requirements are up $117 million in STS operations and down about $217 million in STS capability development, for a net decrease of $100 million.

Pages 4 and 5 summarize the funding plan for the space science and applications program. I have already mentioned the flight activity. You can see for those projects, the funding required in fiscal years 1982, 1983, and 1984, and also the total project cost estimates. Physics and astronomy is up very significantly, about $74 million. That is largely because of the funding increase resulting from the buildup in effort on the gamma ray observatory. There is some augmentation in the payload activity. About $4 million of that payload activity is really for materials processing experiments in fiscal year 1984. There is an augmentation in the Explorer development line, which will enable us to make progress on several missions. The largest of these in 1984, in terms of funding, are the Extreme Ultraviolet Explorer and the Cosmic Background Explorer. There is also some increase in the areas of mission operations, research and analysis, and the suborbital programs. The suborbital pro-

grams consist of the airborne research activities and the balloon and sounding rocket experiments. Life sciences continues at about the same level of activity. Planetary exploration has increased largely because of the initiation of the Venus radar mapper mission, with a partially offsetting decrease in the Galileo funding requirement. If you take all the other areas in planetary exploration together, they retain about the same level between 1983 and 1984. Solid Earth observations—and that name really is to distinguish it from the atmospheric and oceanographic observations from space—are decreasing. This decrease is largely because of completion of the Landsat-4 development and the phaseout of NASA funding on the Agristars project. Efforts in research and analysis, geodynamics, and shuttle payloads show small increases. Payloads in this area include the radar sensors that we were talking about last Thursday as well as the technology work for the multilinear array sensor which is the next generation of earth resources sensor.

On page 5, you can see the increase in effort of environmental observations. The funding for the Earth radiation budget satellite experiment decreases some, and the effort on the upper atmosphere research satellite experiments increases. Materials processing is carried at about the same level in fiscal year 1984 as in fiscal year 1983. In communications, we show a decrease, but that is because we have $20 million in funding for the advanced communication satellite in fiscal year 1983. For fiscal year 1984, we are carrying only $5 million. What that really reflects is that the effort will be the result of a request for proposal that will be responded to by industry in late 1983, and the $25 million total for the 2 years will be applied to initiate that project. We are looking for substantial industry participation in the funding of that project. Information systems efforts increase slightly. Technology utilization is carried at $4 million in this budget request.

On page 6, there is a brief summary of the aeronautics program, which has been increased to $300 million. The research and technology base is up by $30 million, and in systems technology we have increased effort on rotorcraft and on the turbine engine hot-section technology. There is an initiative in the advanced composite structures, and the very important project, the numerical aerodynamic simulation project, which is really a major step forward in computational capabilities in the aerodynamic simulation area.

On page 7, there is a summary of the requirements for space research and technology. You will see that the research and technology base increases by about 10 percent and is the area where we are developing the technology on which our future capabilities in space depend.

Page 8 shows the requirements for space tracking and data systems. The line called space network contains the funding for the tracking and data relay satellite system. We are beginning the repayments to the Federal Financing Bank, and that line also provides for the operation of the system. The operational phase will start after the first two launches, which are scheduled to take place in 1983.

On page 9 there is a summary of the construction of facilities program. We are requesting a total of $150 million. $41 million of that is for space shuttle facilities, and the biggest single item is the

$27 million for the third mobile launcher at KSC. The budget also includes $24 million for aeronautical construction projects, and there is $58 million for the combination of repair, rehabilitation, minor construction, and facility planning. We consider these activities essential to maintaining the effectiveness of our plant to support the research and development program. The item near the bottom of the chart is for $8 million to reimburse the General Services Administration for the property that we use at Ellington Air Force Base near Houston.

Page 10 summarizes the requirement for research and program management. We are requesting $1,247.5 million in that area, which provides for essentially the same level of operation as in 1983. Our civil service staffing is planned to continue at the current level, essentially the present level, and the requirement to fund personnel compensation within this appropriation is $884 million. This amount is based on the salaries that are presently in effect. In other words, we do not project forward salary increases in the budget. The amount for travel is $25.7 million and provides for about the same number of trips as we are planning in 1983. Operation of installation, including utilities, facilities, services, administrative communications, purchased goods and services, require about $338 million in 1984. I would like to add one note on the research and program management appropriation. In fiscal year 1983, we are showing $1,199 million which assumes a supplemental appropriation of $30.2 million. Of course, that request, combined with the $1,168.9 million already appropriated, will cover our requirement for fiscal year 1983. The amount requested for the supplemental appropriation only partially covers the cost of the pay raise. We have made plans to absorb the balance of that requirement.

As shown on page 11, we have made a number of changes in our budget structure. They really are changes that we have made to bring the structure in line with our present mode of operation, and they reflect some of the effects of our reorganization. In space transportation systems, last year we had three lines: Space shuttle, space flight operations, and expendable launch vehicles. We have combined the expendable launch vehicles and the standard shuttle operations into the line that is now called space transportation operations. All other aspects of the space transportation area are covered under space transportation capability development. In other words, we have separated the standard operations from the developmental aspects. In space science and applications, we have made some changes to consolidate some areas. The plasma physics activity, which was carried under physics and astronomy, has been consolidated with the upper atmosphere research efforts under environmental observations. The airborne instrumentation research program has been consolidated under the suborbital program in physics and astronomy, and we have integrated the management of the materials processing payloads with those under physics and astronomy. In aeronautics space research and technology, and space tracking and data systems, acquisition, there have been some internal changes but no adjustment between the major line items. The details of these changes are available in the book. One key point is, when you look at the budget as we have presented it, all the col-

umns are on a comparable basis, so the same program content is in all the columns as you look at the budget.

I have shown on page 12 the fiscal year 1983 operating plan. I have also shown the budget as presented last January and in the Authorization Act. With minor exceptions, the fiscal year 1983 column of the budget is the same as the operating plan that we sent to you in November. The operating plan exceeds the authorization in three areas: In space flight operations, in expendable launch vehicles, and in planetary exploration. We have sent you letters under section 104 of the Authorization Act, and those letters are listed on page 13.

Page 14 is similar to one that we have presented for several years. It is an attempt to show the impact of inflation on the NASA programs. It may be harder to project inflation now than it has been for some time, but the President's budget projects the GNP deflator at 5.6 percent for 1983 and 5.0 percent for 1984. Our experience over the years has been that the inflation we encounter is about 2 percent above the GNP deflator. It is very close to the Bureau of Labor Statistics Index for compensation per hour, and that is as you would expect because our work is labor-intensive. The projections on this page use a 7.5-percent rate for 1983, and a 7-percent rate for 1984. You can see the impact of inflation if you apply those factors to our past actual experience. Since 1976, the budget has just about doubled in the actual dollars appropriated, but if you consider the purchasing power available with those dollars, it has just about broken even over that period.

On page 15 is another economic look at NASA. We have developed an analysis over the years in an attempt to identify how many people really are employed as a result of NASA activities. It is a fairly hard figure to verify, but we base the analysis on the costs at contractors' plants. As best we can tell, we will employ in 1984 about 113,000 people in contractor and subcontractor activities, and about 21,000 NASA civil servants, for a total of about 134,000. If you apply a multiplier effect of 2.5 to that, the total employment generated by NASA programs is something over 330,000. We took a look back at the 1976 situation, and the total employment was about the same, but we have shifted somewhat, as you can see. Civil servants have gone down and contractor employment has gone up.

The final page I intend to address is the projections shown on page 16. The President's budget contains forward projections for the next several years, and the amounts shown here are the NASA figures that are consistent with the projections shown in the President's budget. You can see the projection from 1984 through 1987 on this page. Mr. Chairman, that is all the material that I had intended to present, and I am ready to answer any questions.

[The prepared statement, plus answers to questions asked of Mr. Newman, follows:]

FY 1984 BUDGET OVERVIEW

C. Thomas Newman
Comptroller

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications
Subcommittee on Transportation, Aviation and Materials

of the

Committee on Science and Technology
House of Representatives

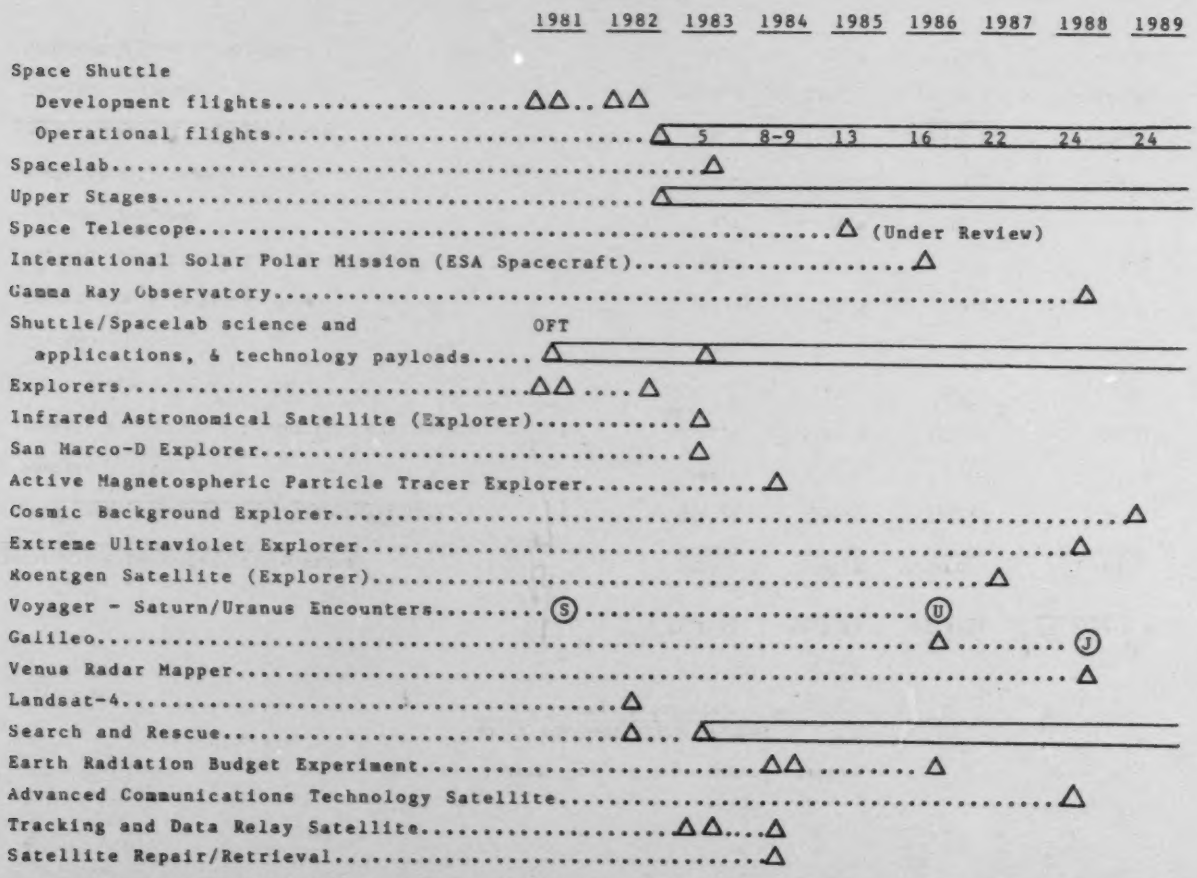
National Aeronautics and Space Administration

BUDGET SUMMARY
(dollars in millions)

	FY 1982	FY 1983	FY 1984
Space Transportation Capability Development	2623.4	2144.1	1927.4
Space Transportation Operations	466.5	1453.7	1570.6
Space Transportation	3089.9	3597.8	3498.0
Physics and Astronomy	322.5	441.0	514.6
Life Sciences	39.5	55.7	59.0
Planetary Exploration	210.0	186.4	205.4
Space Applications	324.2	351.0	289.0
Space Science and Applications	896.2	1034.1	1068.0
Technology Utilization	8.0	9.0	4.0
Aeronautical Research and Technology	264.8	280.0	300.3
Space Research and Technology	111.0	123.0	138.0
Space Tracking and Data Acquisition	402.1	498.9	700.2
Research and Development	4772.0	5542.8	5708.5
Construction of Facilities	113.7	97.5	150.5
Research and Program Management	1134.4	1199.1	1247.5
TOTAL	6020.1	6839.4	7106.5
Outlays	6035.4	6721.5	6981.1

National Aeronautics and Space Administration

FLIGHT ACTIVITY



National Aeronautics and Space Administration

SPACE TRANSPORTATION SYSTEMS
(millions of dollars)

	FY 1982	FY 1983	FY 1984	Change FY 1983 - 1984
TOTAL SPACE TRANSPORTATION SYSTEMS	**3089.9**	**3597.8**	**3498.0**	**-99.8**
Space Transportation Capability Development	**2623.4**	**2144.1**	**1927.4**	**-216.7**
Shuttle DDT&E	894.0	---	---	---
Shuttle Production & Capability Development	1282.8	1729.3	1500.0	-229.3
Upper Stages	106.7	167.0	143.2	-23.8
Spacelab	100.8	121.2	119.6	-1.6
Engineering & Technical Base	183.1	70.3	93.1	+22.8
Payload Operations & Support Equipment	46.3	44.4	53.2	+8.8
Advanced Programs	9.7	11.9	15.0	+3.1
Tethered Satellite	---	---	3.3	+3.3
Space Transportation Operations	**466.5**	**1453.7**	**1570.6**	**+116.9**
Shuttle Operations	435.3	1370.7	1520.6	+149.9
Expendable Launch Vehicles	31.2	83.0	50.0	-33.0

National Aeronautics and Space Administration

SPACE SCIENCE AND APPLICATIONS
(millions of dollars)

	FY 1982	FY 1983	FY 1984	Total Project Cost Estimate
TOTAL SPACE SCIENCE & APPLICATIONS	896.2	1034.1	1068.0	
Physics and Astronomy	322.5	441.0	514.6	
Space telescope	121.5	137.5	120.6	Under Review
Gamma ray observatory	8.0	34.5	89.8	425-475
Spacelab payloads development and mission management	47.6	83.0	92.9	
Explorer development	33.3	34.3	48.7	
Mission operations and data analysis	45.3	74.8	79.5	
Research & analysis	22.9	28.8	29.8	
Suborbital programs	43.9	48.1	53.3	
Life Sciences	39.5	55.7	59.0	
Life science flight experiments	14.0	24.0	23.0	
Research & analysis	25.5	31.7	36.0	
Planetary Exploration	210.0	186.4	205.4	
Galileo	115.7	91.6	79.5	830-910
Venus radar mapper	---	---	29.0	350
International solar polar mission	5.0	6.0	8.0	
Mission operations and data analysis	42.6	38.5	43.4	
Research & analysis	46.7	50.3	45.5	
Solid Earth Observations	149.4	132.2	74.4	
Landsat-4	81.9	61.7	15.8	500-510
Extended mission operations	2.8	1.8	1.0	
Shuttle/Spacelab payloads	12.3	13.8	15.0	
Geodynamics	22.9	26.2	28.0	
AgRISTARS	14.0	15.0	---	
Research & analysis	10.5	13.7	14.6	
Technology transfer	5.0	---	---	

	FY 1982	FY 1983	FY 1984	Total Project Cost Estimate
Environmental Observations	133.0	156.9	163.0	
Upper atmosphere research & analysis	20.5	27.7	29.6	
Atmospheric dynamics & radiation research & analysis	22.3	26.5	28.4	
Oceanic process research & analysis	16.9	17.0	18.2	
Space physics/ATD research & analysis	12.1	15.2	15.7	
Shuttle/Spacelab payload	4.1	3.7	7.6	
Operational satellite improvement program	6.0	6.0	.6	
Earth radiation budget experiment	24.0	24.0	15.5	110-130
Extended mission operations	16.1	22.8	27.4	
Upper atmosphere research satellite experiments & mission definition	6.0	14.0	20.0	200-300
Halogen occultation experiment	5.0	---	---	
Materials Processing	16.2	22.0	21.6	
Communications	21.3	32.4	21.1	
Research & analysis	15.4	5.1	8.5	
Search & rescue	2.3	3.7	3.8	20-24
Technical consultation & support studies	2.6	2.6	2.7	
Experiment coordination & operations support	1.0	1.0	1.1	
Advanced communications technology satellite	---	20.0	5.0	350
Information Systems	4.3	7.5	8.9	
TECHNOLOGY UTILIZATION	8.0	9.0	4.0	

National Aeronautics and Space Administration

AERONAUTICAL RESEARCH AND TECHNOLOGY
(millions of dollars)

	FY 1982	FY 1983	FY 1984	Total Project Cost Estimate
TOTAL AERONAUTICAL RESEARCH AND TECHNOLOGY	264.8	280.0	300.3	
Research and Technology Base	172.7	197.7	227.8	
Systems Technology	92.1	82.3	72.5	
Rotorcraft systems	21.7	22.3	27.6	
Guidance and navigation	1.4	1.5	1.6	
Powered-lift technology	.3	---	---	10.6
Rotor systems research aircraft flight research/rotors	6.0	5.0	3.3	
Tilt-rotor systems	2.6	---	---	6.5
Advanced rotorcraft technology	11.4	15.8	14.7	61.5
Technology for next generation rotorcraft	---	---	8.0	32.0
High-performance aircraft systems	13.8	15.0	19.9	
High-performance flight research	6.2	9.2	8.7	
Highly maneuverable aircraft technology	1.6	.2	---	27.4
Turbine engine hot section technology	6.0	5.6	11.2	
Subsonic aircraft systems	27.0	17.0	5.0	
Energy efficient transport	1.5	3.0	---	80.0
Laminar flow control	8.0	3.0	---	36.3
Advanced transport operating systems	8.6	5.0	---	65.9
Composite primary aircraft structures	8.9	6.0	---	102.9
Advanced composite structures	---	---	5.0	92.0
Advanced propulsion systems	26.2	28.0	---	
Energy efficient engine	16.2	7.0	---	185.8
Advanced turboprop systems	10.0	15.0	---	36.3
General aviation/commuter engine	---	3.0	---	
Broad property fuels	---	3.0	---	
Numerical aerodynamic simulation	---	---	20.0	
Other systems technology	3.4	---	---	38.0

National Aeronautics and Space Administration

SPACE RESEARCH AND TECHNOLOGY
(millions of dollars)

	FY 1982	FY 1983	FY 1984
TOTAL SPACE RESEARCH AND TECHNOLOGY	111.0	123.0	138.0
Research and Technology Base	104.6	115.1	126.2
Systems Technology	3.4	4.9	7.2
Spacecraft systems			
Space flight experiments	1.1	1.9	5.5
Long duration exposure facility	1.6	2.1	.7
Ion auxiliary propulsion system	.7	.9	1.0
Standards and Practices	3.0	3.0	4.6

National Aeronautics and Space Administration

TRACKING AND DATA ACQUISITION
(millions of dollars)

	FY 1982	FY 1983	FY 1984
TOTAL TRACKING AND DATA ACQUISITION	402.1	498.9	700.2
Space Network	21.8	103.8	294.7
Ground Network	237.5	242.4	231.5
Communications & Data Systems	130.3	139.3	159.8
Advanced Systems	12.5	13.4	14.2

National Aeronautics and Space Administration

CONSTRUCTION OF FACILITIES

SUMMARY

	FY 1984 (thousands of dollars)
AMES RESEARCH CENTER	3,900
• Construction of Fluid Mechanics Laboratory	3,900
DRYDEN FLIGHT RESEARCH FACILITY	800
• Construction of Aeronautical Tracking Facility	800
JET PROPULSION LABORATORY	4,300
• Construction of Frequency Standards Laboratory	2,700
• Modifications to Space Flight Operations Facility	1,600
LANGLEY RESEARCH CENTER	9,500
• Modifications and Addition for Composite Materials Laboratory	5,100
• Modifications to 30- by 60-Foot Wind Tunnel (643)	4,400
LEWIS RESEARCH CENTER	10,600
• Modifications for Small Engine Component Testing Facility	7,000
• Modifications to Icing Research Tunnel (11)	3,600
SPACE SHUTTLE AT VARIOUS LOCATIONS	41,300
• Modifications for Additional Chillers for Mission Control Center (JSC)	2,300
• Modification to Mobile Launcher Platform #3 (KSC)	27,300
• Facilities for External Tanks (MAF)	11,700
SPACE SHUTTLE PAYLOAD FACILITIES AT VARIOUS LOCATIONS	12,000
• Construction of Cargo Hazardous Servicing Facility (KSC)	9,000
• Modifications to Spacecraft Assembly & Encapsulation Facility (SAEF-2) for Cargo Processing (KSC)	3,000
VARIOUS LOCATIONS	1,700
• Relocation of 26-Meter STDN Antenna, Spain (JPL)	1,700
REPAIR OF FACILITIES NOT IN EXCESS OF $500,000 PER PROJECT	19,500
REHABILITATION AND MODIFICATION OF FACILITIES AT VARIOUS LOCATIONS, NOT IN EXCESS OF $500,000 PER PROJECT	24,500
MINOR CONSTRUCTION OF NEW FACILITIES AND ADDITIONS TO EXISTING FACILITIES AT VARIOUS LOCATIONS, NOT IN EXCESS OF $250,000 PER PROJECT	4,800
FACILITY PLANNING AND DESIGN	9,200
SUBTOTAL	142,100
REIMBURSE GSA FOR ELLINGTON AIR FORCE BASE PROPERTY	8,400
TOTAL CONSTRUCTION OF FACILITIES	150,500

National Aeronautics and Space Administration

RESEARCH AND PROGRAM MANAGEMENT
SUMMARY OF BUDGET PLAN BY INSTALLATION
(millions of dollars)

Installation	FY 1982	FY 1983	FY 1984
Ames Research Center	101.1	107.4	108.8
Goddard Space Flight Center	169.1	180.9	183.7
Headquarters	109.8	111.9	119.9
Johnson Space Center	186.8	195.2	204.6
Kennedy Space Center	156.0	163.3	173.5
Langley Research Center	126.6	134.2	139.1
Lewis Research Center	106.4	115.9	121.9
Marshall Space Flight Center	172.0	184.0	186.7
National Space Technology Laboratories	6.6	6.3	9.3
Total	1,134.4	1,199.1	1,247.5

SUMMARY OF PERMANENT POSITIONS BY INSTALLATIONS

Installation	FY 1982	FY 1983	FY 1984
Ames Research Center	2,037	2,021	2,021
Goddard Space Flight Center	3,661	3,623	3,623
Headquarters	1,491	1,457	1,457
Johnson Space Center	3,346	3,293	3,293
Kennedy Space Center	2,133	2,112	2,112
Langley Research Center	2,866	2,845	2,845
Lewis Research Center	2,663	2,479	2,479
Marshall Space Flight Center	3,351	3,285	3,285
National Space Technology Laboratories	104	104	104
Total	21,652	21,219	21,219

National Aeronautics and Space Administration

FY 1984 BUDGET STRUCTURE	RELATION TO FY 1983 BUDGET STRUCTURE
Space Transportation Capability Development	Space Shuttle Space Flight Operations except standard Shuttle Operations
Space Transportation Operations	Standard Shuttle Operations Expendable Launch Vehicles
Physics and Astronomy	Physics and Astronomy except ISPM and Space Plasma Physics; plus Aircraft Operations and Materials Payload from Applications
Life Sciences	Life Sciences
Planetary Exploration	Planetary Exploration plus ISPM
Space Applications	Applications except Aircraft Operations and Materials Payload plus Space Plasma Physics
Technology Utilization	Technology Utilization
Aeronautical Research and Technology	Aeronautical Research and Technology
Space Research and Technology	Space Research and Technology
Tracking and Data Acquisition	Tracking and Data Acquisition

SPACE SHUTTLE

SPACE FLIGHT OPERATIONS

EXPENDABLE LAUNCH OPERATIONS

PHYSICS AND ASTRONOMY

PLANETARY EXPLORATION

LIFE SCIENCES

SPACE APPLICATIONS

TECHNOLOGY UTILIZATION

AERONAUTICAL RESEARCH AND TECHNOLOG

SPACE RESEARCH AND TECHNOLOGY

TRACKING AND DATA ACQUISITION

TOTAL RESEARCH AND DEVELOPMENT

CONSTRUCTION OF FACILITIES

*RESEARCH AND PROGRAM MANAGEMENT

TOTAL NASA

*Proposed supplemental to partially

National Aeronautics and Space Administration

FY 1983 OPERATING PLAN - NOVEMBER 18, 1982
(millions of dollars)

	FY 1983 January Budget	FY 1983 Authorization	FY 1983 Operating Plan
	1718.0	1798.0	1703.8
	1707.0	1699.0	1811.0
	42.8	42.3	83.0
	471.7	473.7	461.7
	154.6	177.6	180.4
	55.7	55.7	55.7
	316.3	336.3	336.3
	4.0	9.0	9.0
CY	232.0	280.0	280.0
	123.0	128.0	123.0
	508.9	503.9	498.9
	5334.0	5504.0	5542.8
	100.0	100.0	97.5
	1178.9	1168.9	1168.9
			30.2*
	6612.9	6772.9	6839.4

* cover approved pay raise.

National Aeronautics and Space Administration

OPERATING PLAN/PENDING REPROGRAMMING ACTIONS

Action	Content	Status
Expendable Launch Vehicles - Section 104(2) of NASA Authorization Act (P.L. 97-324)	Exceed Authorization by $40.2 million	signed by the Administrator 1/28/83
Space Flight Operations - Section 104(2) of NASA Authorization Act (P.L. 97-324)	Exceed Authorization by $112.0 million	signed by the Administrator 1/28/83
Space Flight Operations - HUD-Independent Agencies Appropriation Act (P.L. 97-272)	Exceed Appropriation ceiling by $15.0 million	signed by the Administrator 1/28/83
Planetary Exploration - Section 104(2) of NASA Authorization Act (P.L. 97-324)	Exceed Authorization ceiling by $2.8 million	signed by the Administrator 1/28/83

TOTAL NASA

Actual Budget Authority

Inflation Adjustment
Budget Authority in Terms of Constant FY 1976 Dollars

Annual Rate
1976-1982 based on NASA Experience Which Reflects Labor Intensive Nature of NASA Program (Constant dollar amounts for FY 83 & 84 are computed at rates of 7.5% & 7% respectively.)

National Aeronautics and Space Administration

APPROXIMATE EFFECTS OF INFLATION
FY 1984 BUDGET
(millions of dollars)

FY 1976	FY 1978	FY 1980	FY 1982	FY 1983	FY 1984	8-Year Change
3,550	4,064	5,244	6,020	6,839	7,106	+100%
3,550	3,410	3,630	3,434	3,630	3,525	—
—	7.8	10.7	9.4	6-9	6-8	

National Aeronautics and Space Administration

EMPLOYMENT TRENDS

	Private Sector Employment	NASA Employed Civil Servants	Total
June 1976	108,000	24,000	132,000
September 1984	113,000	21,000	134,000

- NASA spending is highly labor intensive--approximately 85% of NASA expenditures provides compensation to workers (79% of R&D dollars)
- NASA employment ranges from low skill maintenance jobs to highly technical scientific and engineering jobs
- Assuming a multiplier effect of 2.5 - NASA expenditures result in about 336,000 jobs

19-605 O—83—8

National Aeronautics and Space Administration

FY 1984 BUDGET MULTI-YEAR ESTIMATES
(millions of dollars)

	FY 1983	FY 1984	FY 1985	FY 1986	FY 1987
Space Transportation Systems	3597	3498	3163	2518	2456
Space Science and Applications*	1043	1072	1246	1238	1194
Aeronautical Research and Technology	280	300	332	351	368
Space Research and Technology	123	138	147	157	166
Tracking and Data Acquisition	499	700	714	693	696
Total FY 1984 R&D Program	5542	5708	5602	4957	4880
Research and Program Management	1199	1248	1263	1277	1292
Construction of Facilities	98	151	110	110	110
Total	6839	7107	6975	6344	6282

*Includes Technology Utilization

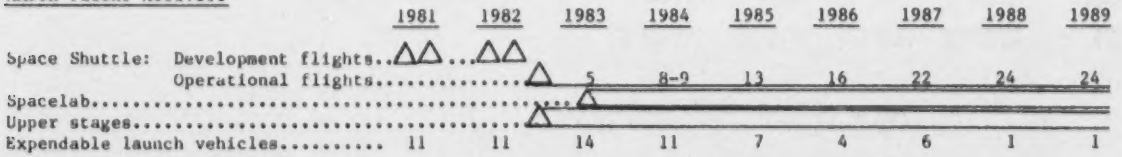
APPENDIX

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE TRANSPORTATION SYSTEMS

- Proceed with operations and development of the capabilities of a versatile and cost-effective space transportation system to provide for:
  - Expanded capabilities employing the reusable Space Shuttle system
  - Manned orbital experiments using Shuttle and Spacelab
  - Deep space and geosynchronous mission capability with upper stages
  - Orbital placement, servicing, and retrieval of automated satellites
  - Economy in transportation, space operations, and payload costs
- First operational flight mission accomplished in November 1982
- Provide support to increased Shuttle operational flight rate
- Continue production to provide a national fleet of Space Shuttle orbiters
- Proceed with development of additional Shuttle performance capability
- Proceed with activities supporting early demonstration of Shuttle on-orbit retrieval and repair capability
- Initiate development of United States-Italian Tethered Satellite System
- Provide expendable launch vehicle services as required by NASA and other users during transition to the Space Transportation System

MAJOR FLIGHT ACTIVITY


1981 1982 1983 1984 1985 1986 1987 1988 1989
Space Shuttle: Development flights
Operational flights
5 8-9 13 16 22 24 24
Spacelab
Upper stages
Expendable launch vehicles 11 11 14 11 7 4 6 1 1

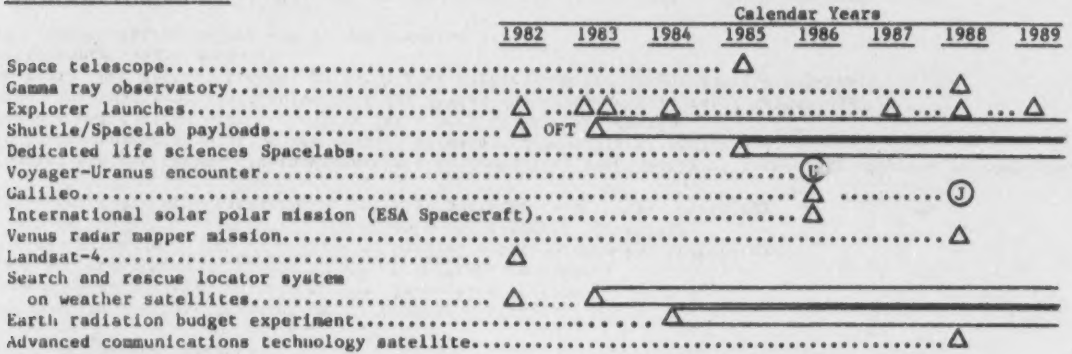
BUDGET PLAN

(millions of dollars)	FY 1982	FY 1983	FY 1984
Space Transportation Capability Development	2623.4	2144.1	1927.4
Space Transportation Operations	466.5	1453.7	1570.6
Total Space Transportation Systems	3089.9	3597.8	3498.0

SPACE SCIENCE AND APPLICATIONS

- Increase our understanding of the evolution and nature of the Earth and its environment, the solar system, and the universe through a balanced program of space exploration missions and ground-based investigations
- Exploit the knowledge gained from current and completed program efforts by thorough analysis and interpretation of the scientific data obtained
- Utilize the space environment for research in the biomedical, biological, and bioinstrumentation fields
- Develop and demonstrate practical uses of space and space-derived technology

MAJOR FLIGHT ACTIVITY



BUDGET PLAN

(millions of dollars)	FY 1982	FY 1983	FY 1984
Physics and Astronomy	322.5	441.0	514.6
Life Sciences	39.5	55.7	59.0
Planetary Exploration	210.0	186.4	205.4
Solid Earth Observations	149.4	132.2	74.4
Environmental Observations	133.0	156.9	163.0
Materials Processing in Space	16.2	22.0	21.6
Communications	21.3	32.4	21.1
Information Systems	4.3	7.5	8.9
Total Space Science and Applications	896.2	1034.1	1068.0
Technology Utilization	8.0	9.0	4.0

National Aeronautics and Space Administration

AERONAUTICAL RESEARCH AND TECHNOLOGY

- Provide the Nation with the fundamental research and technology in the aeronautical disciplines and vehicle classes to:
  - Improve performance
  - Reduce costs
  - Increase safety
  - Reduce energy requirements
  - Decrease environmental effects

- Develop and sustain a strong Research and Technology Base in:
  - Fluid and thermal physics
  - Materials and structures
  - Controls and guidance
  - Human factors
  - Computer science and applications
  - Propulsion systems
  - Rotorcraft technology
  - General aviation/commuter technology
  - Subsonic aircraft technology
  - High-performance aircraft technology

- Conduct focused systems technology to demonstrate the technical feasibility of technology advances or concepts:
  - Numerical aerodynamic simulation for complex aerospace computational problems
  - Advanced composite structures technology for transport aircraft design
  - Technology for next generation rotorcraft for X-Wing and advanced tilt rotor technology
  - Turbine engine hot section technology for higher performance and longer lasting engines
  - high-performance flight research
  - Advanced rotorcraft technology and flight research

- Maintain expertise and operate significant national facilities to support research and technology:
  - Research and test facilities
  - Simulation facilities
  - Wind tunnels

BUDGET PLAN (millions of dollars)	FY 1982	FY 1983	FY 1984
Aeronautical Research and Technology	264.8	280.0	300.3

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SPACE RESEARCH AND TECHNOLOGY

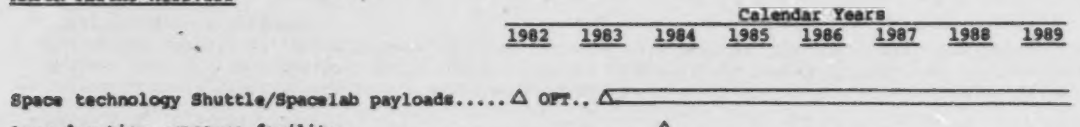
o Provide a technology base essential to future United States leadership in space by:

- -- Improving performance and effectiveness
- -- Reducing cost and risk
- -- Increasing reliability
- -- Developing technological options

o Achieve these objectives, by means of ground and space-based research and technology activities, through advances in the technology areas of:

- -- Fluid and thermal physics
- -- Materials and structures
- -- Computer science and electronics
- -- Chemical propulsion
- -- Space energy conversion
- -- Controls and human factors
- -- Space data and communications
- -- Multidisciplinary research
- -- Spacecraft, transportation, and platform systems
- -- Component standardization

MAJOR FLIGHT ACTIVITY



BUDGET PLAN

(millions of dollars)	FY 1982	FY 1983	FY 1984
Space Research and Technology	111.0	123.0	138.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TRACKING AND DATA ACQUISITION

- Worldwide networks of ground stations interconnected with highly reliable communications to provide support to:
  - -- Shuttle operational flights
  - -- Automated Earth orbiting missions - supports applications and scientific spacecraft including the Nimbus, Landsat, International Ultraviolet Explorer, International Sun-Earth Explorer, Applications Technology Satellites, Solar Maximum Mission, Infrared Astronomical Satellite, Dynamics Explorer, and Solar Mesosphere Explorer
  - -- Planetary missions - support will continue for Pioneers-10 and 11, Pioneer Venus, and Voyagers-1 and 2, as well as limited support for Helios and earlier Pioneer missions
  - -- Sounding rockets
  - -- Aeronautical flight research program
- The Tracking and Data Relay Satellite System (TDRSS) will replace most ground stations in providing tracking, command and telemetry services to all low-Earth orbital missions. The first spacecraft will be launched in early 1983 and the second in mid-1983. The TDRSS contract has been restructured to provide for a dedicated government system.

MAJOR FLIGHT ACTIVITY

	Calendar Years							
	1982	1983	1984	1985	1986	1987	1988	1989
Tracking and Data Relay Satellite..... (Backup satellites available)	△	△	...△					

BUDGET PLAN

(millions of dollars)	FY 1982	FY 1983	FY 1984
Tracking and Data Acquisition	402.1	498.9	700.2

National Aeronautics and Space Administration

BENEFITS OF NASA PROGRAMS

- Tangible effects on the economy through creation of productive high-technology employment opportunities nationwide
- Intangible benefits realized through exploration of challenging and stimulating new frontiers
- Major contributions to National Security from:
  - Technology advances in high-speed aircraft and advanced rotorcraft
  - Wind tunnel and flight testing of new aircraft developments
  - Improvements in communications, weather, and remote sensing satellite systems
  - Shuttle capability to launch and to retrieve or repair critical payloads
- Practical applications and technology transfer in:
  - Resource observations and identification
  - Earth sciences and mapping
  - Environmental observations and monitoring
  - Weather observations and forecasting
  - Space and ground support communications systems
  - Search and rescue
- Secondary transfer of aerospace technology:
  - Energy resources and conservation
  - Medicine, life science and biological technology
  - Consumer products and manufacturing processes
  - Construction methodology and techniques
  - Computational capabilities
- Advances in technology that enhance United States competitive position in worldwide markets
- Stimulates progress in basic research and in space science and technology
- Improvements in aviation safety, efficiency and environmental acceptability
- Promotion of international cooperation

National Aeronautics and Space Administration

SUMMARY OF BUDGET PLANS BY INSTALLATION BY APPROPRIATION

(millions of dollars)

	Total			Research and Development			Construction of Facilities			Research and Program Management		
	1982	1983	1984	1982	1983	1984	1982	1983	1984	1982	1983	1984
Johnson Space Center	1,789.2	1,723.3	1,596.2	1,598.5	1,524.9	1,385.5	4.2	3.2	6.1	186.5	195.2	204.6
Kennedy Space Center	591.4	664.7	739.6	415.5	496.0	524.5	19.9	5.4	41.6	156.0	163.3	173.5
Marshall Space Flight Center	1,395.8	1,784.8	1,814.5	1,200.0	1,577.3	1,608.3	23.7	23.5	19.5	172.1	184.0	186.7
National Space Technology Laboratories	18.6	15.7	20.9	9.9	7.1	7.2	2.1	2.3	3.5	6.6	6.3	9.3
Goddard Space Flight Center	788.8	933.1	974.8	614.6	740.4	774.7	5.1	11.8	6.4	169.1	180.9	183.7
Jet Propulsion Laboratory	319.7	323.6	355.2	316.2	319.7	346.1	3.5	3.9	9.1	—	—	—
Ames Research Center	298.8	293.6	324.1	175.3	176.3	205.0	22.4	9.9	10.3	101.1	107.4	108.8
Langley Research Center	262.7	286.7	289.9	129.6	132.9	134.7	6.5	19.6	16.1	126.6	134.2	139.1
Lewis Research Center	285.6	373.8	368.1	175.1	250.9	229.8	4.1	7.0	16.4	106.4	115.9	121.9
Headquarters	246.9	429.2	612.6	137.2	317.3	492.7	—	—	—	109.7	111.9	119.9
Undistributed Construction of Facilities:												
Various Locations	12.2	2.6	3.9	—	—	—	12.2	2.6	3.9	—	—	—
Facility Planning and Design	10.0	8.3	9.2	—	—	—	10.0	8.3	9.2	—	—	—
Total Budget Plan	6,019.7	6,839.4	7,098.1	4,771.9	5,542.8	5,708.5	113.7	97.5	142.1	1,134.1**	1,199.1***	1,247.5
			8.4*						8.4*			
			7,106.5						150.5			

* Reimbursement to GSA for NASA utilized property of Ellington, AFB, Texas as directed by OMB

** Excludes $.3 million lapsing

*** Includes $30,150,000 for increased pay cost

FY 1984
MAJOR ACTIVITIES BY CENTER

AMES RESEARCH CENTER/DRYDEN FLIGHT RESEARCH FACILITY

- Aeronautical research and technology
  - Theoretical and experimental aerodynamics, computation fluid dynamics, fluid and thermal physics
  - Rotorcraft technology, high-performance aircraft technology
  - Flight simulation, flight testing
  - Human factors
  - Numerical aerodynamic simulation capability
- Space research and technology
  - Entry technology, materials research, project support (e.g., Shuttle, OEX, Galileo probe, infrared astronomy)
- Life sciences (biomedical support systems, nonhuman biological experiments)
- Airborne astronomy, infrared astronomy (Infrared Astronomical Satellite), and Shuttle Infrared Telescope Facility
- Galileo probe project management
- Shuttle contingency landing site (DFRF)
- Space applications
  - Earth and environmental observations (space, atmospheric, and statospheric programs), airborne platforms
- Space station technology development

GODDARD SPACE FLIGHT CENTER/WALLOPS FLIGHT FACILITY

- Development of Earth orbital spacecraft and experiments for space applications and space science
- Sounding rocket and balloon development, procurement, launch and operations
- Aeronautical flight test support (Wallops)
- Experiment management support to environmental observations in weather and climate and ocean dynamics
- Physics and astronomy explorers
- Tracking and data acquisition - Tracking network/Tracking and Data Relay Satellite
- Management of Delta launch vehicle program
- Spacelab payload development and mission management of special payloads
- Science instruments for Space Telescope and Space Telescope operations
- Upper Atmospheric Research Satellite Experiment and mission definition management
- Scientific research including both theoretical studies and experiment development

JET PROPULSION LABORATORY

- Planetary exploration development management and operation of planetary spacecraft and experiments
- Galileo project management
- Voyager project
- Venus Radar Mapper project management
- Infrared Astronomical Satellite project management
- International Solar Polar Mission instruments and support
- Tracking and data acquisition - operation of Deep Space Network
- Network consolidation - Spaceflight Tracking and Data Network and Deep Space Network
- Space and terrestrial energy research and technology

JOHNSON SPACE CENTER

- Overall Shuttle management
- Shuttle orbiter and systems integration production and logistics
- STS operational flight planning, flight control, and crew training
- Interpretive techniques using Landsat data
- Life sciences in-flight experiment development, flight crew monitoring and physiological requirements for manned spacecraft systems
- Advanced concept studies for manned space flight
- Space station definition

KENNEDY SPACE CENTER

- Shuttle launch and landing operations and facilities
- Shuttle payload integration
- Spacelab integration and launch
- Launch of payloads on expendable launch vehicles from both Eastern Space and Missile Center and Western Space and Missile Center

LANGLEY RESEARCH CENTER

- Aeronautical research and technology
  - Subsonic aircraft technology, fuel efficiency
  - Materials and structures
  - Theoretical and experimental aerodynamics
- Space research and technology
  - Materials and structures
  - Entry technology, technology experiments in space
  - Space energy conversion
  - Electronic component technology, information systems, sensor research

Responses to Written Questions from the Joint House Hearing on February 8, 1983, at which Mr. Newman testified.

QUESTION B-1:

(a) Mr. Newman, in your analysis of the impact of inflation what rates are assumed for fiscal year 1983 and 1984?

(b) How does NASA experience compare with the GNP deflator?

(c) How do aerospace industry costs compare with the national average?

ANSWER B-1:

(a) We are assuming effective inflation rates in our programs of 6 to 9 percent in 1983 and 6 to 8 percent in 1984.

(b) Historically, the NASA R&D inflation has been somewhat higher than the GNP Deflator because price movement in R&D is heavily driven by the increase in labor compensation. The historical R&D inflation has tracked well with the Bureau of Labor Statistics Compensation Index. The current economic situation, however, appears to have affected the overall national wage growth trends more than those in the aerospace industry. The basic explanation for the performance of R&D inflation relative to the GNP Deflator is that the latter typically measures price changes of goods and services across the economy where labor cost increases are partially offset by increases in capital investment and other improvements in economies of scale.

The NASA R&D inflation directly measures: (1) price change for labor where little economy of scale offset is possible; and (2) the price change for unusual and often scarce materials and parts.

(c) Currently, our data shows that the price of labor in the space and missile industry is rising faster than the national average, apparently because the defense expenditures in the aerospace industry maintains the rate of compensation growth near that experienced over the last few years.

QUESTION B-2:

You have noted that the Space Telescope program costs are under review. Is an independent cost and schedule review of this program planned by your office?

ANSWER B-2:

A NASA cost and schedule review of Space Telescope is currently in process. A member of my immediate staff is participating in this review. I will review the findings and conclusions made by the Space Telescope review team including the analysis done by my staff members. All of this data will be utilized in assessing the cost and schedule impact of the current Space Telescope problems.

QUESTION B-3:

NASA has initiated development of a lighter weight filament wound case for the Solid Rocket Boosters.

(a) What is the cost and schedule status of this activity?

(b) What is the total cost estimate for this program?

ANSWER B-3:

(a) During May 1982, authority to proceed on the Filament Wound Case development was provided to the Thiokol Corporation as a prime contractor with Herculese as the major subcontractor. Through the end of FY 1982, $16.4 million had been obligated to support this development and its integration into the Shuttle system. Planned obligations for FY 1983 are $55 million. The major program milestones include the first firing during April 1984, completion of the Critical Design Review during August 1984 and delivery of the first flight set to Vandenburg Air Force Base by April 1985 in order to support an October 1985 launch.

(b) The Filament Wound Case program is estimated to cost $223 million (real year dollars) to include development, integration into the Shuttle system, and the first three flight sets of hardware.

QUESTION B-4:

NASA has a number of new starts in the budget--Venus Radar Mission, Tethered Satellite, Advanced Communications Technology Satellite, and the Numerical Aerodynamic Simulator. What is the projected total cost for each of these programs?

ANSWER B-4:

The following is a listing of the total estimated cost of the new initiatives included in the FY 1984 Budget Request:

- Venus Radar Mapper (VRM) Mission	$350 - 400 million
- Advanced Communications Technology Satellite (ACTS) Payload	$325 - 425 million [1/]
- Tethered Satellite	$40 - 50 million [2/]
- Numerical Aerodynamic Simulation (NAS)	$110 - 130 million through FY 1988 [3/]

1/ Assumes that industry will share in the total cost of the satellite project.

2/ Cooperative project with Italy; this estimate is for the U.S. portion only.

3/ The NAS capability will be a continuously upgraded system. This estimate is the projected runout range through FY 1988 only; however the project will be continued after that time. By 1988, NAS speed (1 gigaflop) and memory will allow three-dimensional viscous flow simulation over an entire aircraft shape thus shortening expensive wind tunnel testing.

QUESTION B-5:

You have included FY 1984 budget multi-year estimates through fiscal year 1987.

(a) What inflation rates did you assume?

(b) Are any new starts assumed?

ANSWER B-5:

(a) The multi-year estimates for the NASA FY 1984 program through FY 1987 assume average inflation rates of 7.0 percent for FY 1984 and about 6 percent for subsequent years.

(b) The multi-year estimates are essentially a runout of the FY 1984 program. In the near term, FY 1985 and FY 1986, there is no provision for new starts.

QUESTION B-6:

Could you elaborate on the impact of inflation on the NASA budget?

ANSWER B-6:

Inflation has had a dramatic impact on NASA budgets. Since 1976, our budget has about doubled; but in terms of purchasing power, we have remained essentially at the 1976 level.

QUESTION B-7:

What is the current rate of inflation being experienced in NASA procurements?

ANSWER B-7:

NASA is currently experiencing 6 to 9 percent inflation rate in its procurements.

QUESTION B-8:

(a) What is your assessment of the impact of NASA spending on inflation?

(b) Has NASA recently performed any studies which assess the impact of NASA spending.

ANSWER B-8:

(a) NASA spending is assessed to have no adverse long-run inflationary effects on prices and cost in the operation of the national economy. NASA expenditures are labor intensive, with approximately 85 percent of spending directly for jobs and the remainder for materials. NASA employs about 21,000 civil servants and supports about 113,000 contractor employees. Assuming a multiplier effect of 2.5, the total, short-run employment effect on the United States' econonmy is about 336,000 jobs. This number is not large enough to have a significant national effect, although

there could be some specific cases of industrial and regional employment and price changes influenced by NASA expenditures.

(b) NASA has not performed recent studies on the impact of NASA spending. Past studies have indicated the most significant economic effects of NASA spending are the long-run productivity advances from new technologies developed for the space and aeronautics programs. Many NASA sponsored advances in air and space and transportation, communications satellites, remote sensing satellites, and other innovations have improved the productive capacity of industry and stimulated the development growth of many new businesses. These expanded business opportunities have and are expected to continue to stimulate more productive, non-inflationary private sector economic growth and job creation.

Although it is difficult to assess the results of the various macroeconomic studies of the effects of NASA spending on GNP, it is apparent from analyses done by the Midwest Research Institute, Mathematics, Inc., and others, that NASA high technology R&D expenditures have returned more to the economy in substantial and long-lasting productivity gains than has been spent. Since these gains are through spin-off commercials advances, they are "extra" returns above and beyond the primary goal of NASA programs: the successful completion of the various R&D mission assignments to meet public sector needs. Therefore, any gains which show positive economic returns in the long-run indicate a non-inflationary, signficant return to the citizens of the United States.

Mr. VOLKMER. Thank you very much, Mr. Newman. The gentleman from New Mexico, we will proceed under the 5-minute rule for questions. Mr. Lujan?

Mr. LUJAN. Thank you very much, Mr. Chairman. All of the projections seem to have an upward swing, except for the space transportation systems and space science applications. Is that because we have already done all the purchasing; we assume that they are going to operate really fine; and we do not have to acquire any more after the fourth?

Mr. NEWMAN. Yes, sir.

Mr. LUJAN. It is not that we are going to decrease the space transportation division over in NASA?

Mr. NEWMAN. No. Within those projections, the operations segment increases. The procurement goes down because the fourth orbiter is scheduled for delivery in December 1984. So it essentially will be completed during fiscal year 1984.

Mr. LUJAN. I have not looked at this budget very carefully before this year, but it seems to me to operate a $7 billion agency with an operations cost of $1.2 billion is not bad. As a matter of fact, I look at it as reasonable, if you can call $1 billion reasonable. By percentage, I would say that is doing a very good job.

Mr. NEWMAN. A very substantial portion of the people funded out of that $1.2 billion are, in fact, scientists and engineers working at the centers on research and development projects.

Mr. LUJAN. Your construction facilities of $150 million also seems rather low. We were discussing facilities yesterday in the previous subcommittee where I was ranking, the Energy Subcommittee. Three years ago we found the various laboratories rather in need of additional space. Do you find that within the NASA laboratories? Did you just ask OMB for $150 million, or did you ask for more? And if you did ask for more, for what reasons? Let me lay the groundwork, if I may. One of the laboratories that I will use as an example in DOE was Sandia. When we went to look at it, we found offices in trailers and just almost everywhere that they could put a shoebox, I suppose. So we had to move to find some office space and laboratory space. I understand that is the same situation you have at Goddard.

Mr. NEWMAN. Goddard is rather crowded.

Mr. LUJAN. Was there a request into OMB to cure that situation? Can you answer that sort of question, by the way?

Mr. NEWMAN. Yes, sir, we will respond to questions of that type. We did request $157 million of OMB, so we got most of what we requested. There was a project for an addition to the research projects laboratory at Goddard which was one of the items deleted. There was also some rehabilitation work over at the Wallops Center, near Chincoteague Island, that was deleted. But we got most of what we asked for this year. We have been concerned over the years——

Mr. LUJAN. Is that lack of space critical at Goddard?

Mr. NEWMAN. I am not really qualified to give you a good answer to that question. We did have a project that would have helped somewhat on that situation. I believe they do have a good deal of equipment in the halls.

Mr. LUJAN. It does not make for very good working conditions. This tethered satellite kind of intrigues me, maybe because of the name. Do you hold it down?

Mr. NEWMAN. It is a small ball on a very long wire that is reeled out from the shuttle. The intent is to reel it down into the upper atmosphere. The shuttle will be up above the atmospheric drag. You can put a satellite of a light-weight into the upper atmosphere where there is some drag and take measurements there. If you did it with a free-flying satellite, the satellite would slow down and reenter.

Mr. LUJAN. It won't burn?

Mr. NEWMAN. I am not an expert, but if it is at a high enough altitude, where the drag is not excessive, then the heating would not be excessive.

Mr. LUJAN. Is that $3.3 million our share, or is it the total between us and the Italians.

Mr. NEWMAN. The $3.3 million is our share in fiscal year 1984. For the total project, our portion is something above $40 million. The Italians are also putting something like $30 million into it, over several years.

Mr. LUJAN. Are we finished with all the information we can get out of Landsat? Is that why it is going down from $61 to $15?

Mr. NEWMAN. What that reflects, sir, is that the major development of the Landsat spacecraft is completed. The Landsat-4 satellite, as you may remember, has two major types of sensors. One is

the multispectral scanner. That is a sensor with which we have a great deal of experience, and the National Oceanic and Atmospheric Administration is taking over operation of the satellite and that sensor.

Mr. LUJAN. Is there money in their budget for that?

Mr. NEWMAN. Yes, sir. The second sensor is a thematic mapper, which is an experimental sensor, and is providing much higher resolution. We will still be operating and experimenting with that sensor for the next 18 months or 2 years. Then we will turn that over to NOAA also.

Mr. LUJAN. I have a couple of quick questions, because I am afraid I am running out of time. The tracking and data relay satellites—when will we have those three up there? And the followup question to that concerns the closing down of the ground stations which necessarily follows that.

Mr. NEWMAN. The first satellite will be launched on this next flight, which will be about the first of March, we hope. The second one, about midcalendar 1983. Now, actually, you have an operational system with two satellites. The spare will be launched in early 1984. On the ground station closings, we are providing for a period of overlap while the satellites are checked out. But the ground station closings are scheduled to start in the spring of 1984. By late 1984, I believe, all the stations will be closed, with the exception, of course, of the three that remain open permanently: Madrid, the one in Goldstone, and the one in Australia. They are also deep-space network stations. I would appreciate your checking this with Mr. Smiley, but I believe the one in Bermuda will stay open for a while to support launches out of KSC.

Mr. LUJAN. The chairman asked how that would have an impact on Goddard.

Mr. NEWMAN. Goddard will be the center into which the data for the tracking and data relay satellite system comes. It initially is received at White Sands, but much of the data is transferred to Goddard. Because of the higher data rates, Goddard will have a very large function in handling the data.

Mr. LUJAN. What kind of operation is that going to be for White Sands? Is that for just sitting there and relaying the information on to Goddard? Will White Sands play quite an important part in it, or will it be the receiver that then moves information on to Goddard?

Mr. NEWMAN. It is basically a reception and relay station, but there are some software operations that need to be there. There is sorting of the data stream.

Mr. LUJAN. A lot of people?

Mr. NEWMAN. It will be a contractor-operated facility, operated by SpaceCom, Inc. As for the numbers of people, I cannot pull it out of my head right now. It is not a huge operation. I believe there will not be any civil servants there. It will be operated by employees.

Mr. LUJAN. I may have questions later on, Mr. Chairman, but I think my time is up.

Mr. VOLKMER. Thank you very much, Mr. Lujan. At this time I will recognize the gentleman from Florida, Mr. Nelson, for 5 minutes.

Mr. NELSON. Good afternoon. Could you analyze for me the loss in expected revenue as a result of the Ariane competition and what reduction you see over the next few years in the flight rate as a result of Ariane taking some of our customers?

Mr. NEWMAN. I would much rather do that for the record. There are a number of customers that were double booked and some even triple booked on the shuttle, the Delta launch vehicle and Ariane. I have seen the number that went to Ariane, but I am reluctant to try to pull that out of my head.

[The information follows:]

As of this date, seven payloads have definitively switched from U.S. carriers to the Ariane. These include two Centaur class Intelsat V payloads and five Delta class SSUS-D user commercial payloads (Western Union, GTE (2) and Southern Pacific Satellite Co. (2)). In each case these customers had previously provided earnest money payments to NASA to obtain launch commitments, were booked on the shuttle and in most cases double booked on a Delta or Atlas Centaur and subsequently cancelled their launch shots in order to firmly commit to Ariane. The effect on anticipated reimbursements, assuming that they would have flown on the Shuttle, would be $90 million.

Recent problems with the Ariane launch schedule have tended to stabilize the near term Shuttle commitments. The longer term concern is that additional customers may switch to Ariane as their problems are resolved. Although we do not have access to the Ariane internal launch commitment assumptions, nine of the currently manifested Shuttle payloads have indicated that they are double booked on Ariane. The total estimated potential Shuttle reimbursement amount involved for these payloads is approximately $300 million. Since the potential loss of these customers could be at least partially offset by reductions in flights and operations costs, loss of the projects revenue does not necessarily mean loss to the U.S. government.

Mr. NELSON. Why did those customers that were double booked decide to go with the booking on Ariane instead of the shuttle?

Mr. NEWMAN. My understanding is, it is primarily a matter of price and financing.

Mr. NELSON. And in what years are we speaking about?

Mr. NEWMAN. Primarily in 1985–86.

Mr. NELSON. So Ariane hit a price structure which they are charging their customers that, per flight, per payload, is less than we had originally set as our price per payload, even as early as 1985?

Mr. NEWMAN. They are offering very competitive prices and financing arrangements, yes, sir.

Mr. NELSON. Through the Government subsidizing. I understand that. What degree of differential in the price was there?

Mr. NEWMAN. They seem to be pricing just slightly less than we are. I would have to provide that for the record. It seems to me they were offering a price of about $28 million for payloads of the Delta variety. The Delta mission on a comparable version would be about $37 million or $38 million. The shuttle price for a Delta-type payload would be less.

Mr. NELSON. Is it in 1985 and 1986. If the shuttle price is less than the $28 million offered by Ariane, what is the reason they are not going on the shuttle then? Is it the fact that our program has been slowed down and we do not have the availability in 1985 and 1986?

Mr. NEWMAN. At some point, some of them seemed to be taking that into account. Then, as I said, the price is one factor. The financing arrangements, in many cases, are quite favorable within

the price range. We require a schedule of payments starting 33 months before the launch, and apparently financing arrangements available to Ariane customers are more favorable than that. Even though the price may be equivalent or less, the customer will take the more favorable arrangement.

Mr. NELSON. Let me see if I have this correct. The approximate price of an Ariane payload is $28 million. The approximate price of a shuttle payload is less than $28 million. And the approximate price of a Delta expendable booster rocket is $30 million.

Mr. NEWMAN. More than that for the Delta, above $38 million.

Mr. NELSON. If the choice for a customer is with the French Ariane as opposed to an expendable booster, obviously they are going to take the Ariane. But the competitor for which Ariane was developed was the shuttle, so can I conclude that we are losing customers to the French Ariane because the shuttle is not ready in that timeframe, of 1985 and 1986?

Mr. NEWMAN. As we stand now, we do have launch spots available in that period. But, at the time, customers had to make their choices. I think, the projected availability of launches in that period has been a factor.

Mr. NELSON. So the slowdown in the overall shuttle program has caused us to lose customers to the Ariane?

Mr. NEWMAN. I think that it is correct to conclude that since the schedule uncertainty caused some losses.

Mr. NELSON. The last time they launched an Ariane, it blew up. When is the next Ariane supposed to be launched?

Mr. NEWMAN. We will have to get that for the record, but I believe I have heard a date within the May timeframe.

[The information follows:]

It is our understanding that the new Ariane launch will be scheduled in the May-June 1983 period, depending upon the successful completion of the validation testing of the fixes to the third stage.

Mr. NELSON. So I guess I would infer, then, that if the next May flight of Ariane is successful, we would proceed with these lost customers. Now, how many years into the future did we project that we have these available slots that are empty on our shuttle?

Mr. NEWMAN. Because customers are required to sign up 3 years in advance, as you get out beyond 1986, there do become spaces available on the missions in the post-1986 period.

Mr. NELSON. Is 1986 when our new pricing structure takes effect?

Mr. NEWMAN. Yes, sir. The new pricing structure runs in 1986, 1987, and 1988.

Mr. NELSON. So, even though we have the slots available out there, the fact is that we are going to be faced with a higher cost to the customer per payload in 1986, 1987 and 1988. So we become less competitive from 1986 onward?

Mr. NEWMAN. If you launch on a Delta vehicle, for example, the price for that is in the range of $37 million and possibly a little more, depending on the upper stages. A similar payload launched on the shuttle, in the prices in effect in that time period, would be about $25 million. The estimated cost for a payload on the Ariane would be about equivalent to the shuttle in that time period.

Mr. NELSON. Which time period is that?

Mr. NEWMAN. In 1986.

Mr. NELSON. About $25 million apiece?

Mr. NEWMAN. Yes. I think I told you $28 million a couple of minutes ago. But it probably is more like $25 million in that time period.

Mr. NELSON. The shuttle is $25 million per payload in 1986 and onward?

Mr. NEWMAN. For a Delta-class payload.

Mr. NELSON. What about for a shuttle?

Mr. NEWMAN. For a full-up shuttle mission, the price is based on $38 million in 1975 dollars, which equates to about $80 million in dollars of that period.

Mr. NELSON. Now, compare that to the payload going into the Ariane?

Mr. NEWMAN. The shuttle cost for a payload of that size would be about $25 million. The shuttle, of course, could carry multiple payloads, under proper conditions, possibly as many as four. The Ariane, we believe, in that period would be capable of carrying two Delta-sized payloads, with a total mission cost on the order of $50 million or something again like $25 million for a Delta-sized payload.

Mr. NELSON. So, $25 million for the Ariane. A comparable-size payload on the shuttle for 1986 and beyond is approximately equal?

Mr. NEWMAN. About the same, of course, we are projecting a pricing policy on the part of the Ariane that I cannot really tell you is what they will finally end up with.

Mr. NELSON. From what you have told me, I can conclude that beyond 1986, everything should be equal as far as our competitiveness, unless the French come in and undercut us some more; is that correct?

Mr. NEWMAN. Yes.

Mr. NELSON. So the disadvantage that we are suffering right now is that in the timeframe 1984 to 1985, we cannot be competitive with the Ariane; is that correct?

Mr. NEWMAN. At the time the decisions were made on missions in the 1984 to 1985 period, scheduling of the shuttle program was a heavy consideration. Many of those decisions were made before the Ariane failure. So, I think both scheduled availability, price, and financing arrangements are all considerations the users would face. The factors would have an effect on their choice.

Mr. NELSON. The fact is, if we are outbid—and I will end with this question, Mr. Chairman—in this timeframe, between now and 1986, we have, barring some major accident by the next Ariane which might cause the customers to come flocking back to us, lost a number of customers that probably would have every reason, price being equal beyond 1986, for staying with Ariane. I would appreciate exploration on this in detail for the record.

Mr. NEWMAN. Yes, sir.

[The information follows:]

In the first three years of Shuttle operations (fiscal year 83-85), NASA has lost several customers to Ariane. Specifically, three U.S. firms (Southern Pacific Communications Company, GTE Satellite Corporation, and Western Union Telegraph Company) and one international organization (INTELSAT) selected Ariane over Shuttle to launch their telecommunications satellite payloads. Despite the Shuttle

offering a distinct pricing advantage over Ariane ($7–10 million per launch), the three U.S. firms were swayed in their "business decision" by three factors.

The first factor was launch schedule assurance. At the time these firms scheduled their launches, the Shuttle schedule was projected to be full in their period of interest and we could not initially show them on the Shuttle schedule for the dates they requested. However, their payloads were also booked for launches on the NASA Delta expendable launch vehicle close to their requested launch dates. Although NASA assured them that schedule shifts by other payload customers were bound to occur that would allow their payloads to advance to desired Shuttle launch dates, they were unwilling to accept this risk. (Indeed, as we had advised them, these shifts did occur and their schedule requirements could have ultimately been accommodated on the Shuttle.) Further, at a time when the Shuttle had not yet flown and there were continuing delays in the first flight due to development problems, they were skeptical of NASA's ability to hold the announced Shuttle launch schedule with a sophisticated, manned launch vehicle vis-a-vis a more traditional, though also new, unmanned expendable launch vehicle. (With the completion of the Shuttle flight test program and the first operational launch, this concern is now beginning to dissipate.)

The second factor involved price and financing. The "package deal" offered by Ariane which not only offered a launch price considerably lower than that for a Delta expendable launch vehicle, although somewhat higher than Shuttle, and also included attractive financing. At a time when U.S. interest rates were averaging 15–17 percent, Arianespace, through its French and German banking partners, offered financing packages with interest rates of 11–12 percent and repayment schedules that didn't begin until six months after launch, so that the loans could be repaid from the revenue generated by the satellite. (With the assistance and support of the Export-Import Bank, NASA has been successful meeting this aspect of the Ariane competition when dealing with non-U.S. customers, but we have not yet been able to assist U.S. customers in a similar manner. NASA is continuing to work with the U.S. banking community to attempt to offset this financing disadvantage.)

The third factor was launch vehicle payload weight capability. Although the Shuttle has a much larger payload capability than the Ariane, a telecommunications satellite launched on the Shuttle requires an additional propulsive stage to boost the satellite from the low Earth orbit of the Shuttle to the 23,000 mile altitude required for such a satellite. The propulsive stage initially developed for this purpose would deliver to orbit approximately 100 pounds less per satellite than Ariane was able to offer because the Ariane launch site is located closer to the equator than the Kennedy Space Center. For a telecommunications satellite, this 100 pound difference means enough additional attitude control propellant to extend the useful lifetime of the satellite by one year, with an attendant $20–30 million in additional revenue. (The McDonnell Douglas Corporation is currently modifying the design of their propulsive stage to more than account for this difference, so that the advantage should be reversed by 1985.)

The decision by INTELSAT to initially split their INTELSAT-V launch requirements between the Shuttle and Ariane was based on somewhat different factors. First, Ariane launches were offered to them at a price that was actually $1–2 million less than the Shuttle price. Second, as an international organization with strong French participation, there was a political factor that also influenced the INTELSAT decision.

In summary, while NASA did lose several customers to Ariane, we have gained considerable experience dealing in a competitive market and are aggressively addressing the remaining factors of the Shuttle-Ariane competition, consistent with appropriate constraints on the U.S. government role in commercial enterprises and administration policies in international trade.

Mr. NELSON. Thank you, Mr. Chairman.

Mr. VOLKMER. The Chair will now recognize the gentleman from California, Mr. McCandless.

Mr. MCCANDLESS. Thank you, Mr. Chairman. I have no statements at this time, but I would like to reserve the right to submit questions at a later date, without objection.

Mr. VOLKMER. If you will submit them to him within a timely manner so that they can be included in the record, that would be agreeable.

Mr. MCCANDLESS. Thank you.

Mr. VOLKMER. At this time, the Chair will recognize the other gentleman from Florida, Mr. MacKay.

Mr. MACKAY. No questions, Mr. Chairman.

Mr. VOLKMER. The Chair recognizes Mr. Boehlert from New York.

Mr. BOEHLERT. No questions, Mr. Chairman.

Mr. VOLKMER. Mr. Torricelli, the gentleman from New Jersey.

Mr. TORRICELLI. Thank you, Mr. Chairman. I wonder, being a new member of this subcommittee, if you could respond to this question. In regard to shuttle missions and the use of the shuttle payload facilities for private contractors, to what extent does the cost that you outlined earlier actually reflect the cost of development of the service? This would give some sense of the degree that it is subsidized or, on the other side, that we are recovering costs of development? Is there a way to respond to that?

Mr. NEWMAN. On development, it is very simple. We are not recovering the cost of the shuttle development. As far as the procurement goes, we do have the use charge for commercial customers through 1985. We do not charge Government customers. A use charge is a charge for the use of both the facilities and the permanent hardware.

Mr. TORRICELLI. How are you calculating the cost of the $30 million or whatever the cost might be?

Mr. NEWMAN. The $38 million equivalent, which is the cost basis for our, charge in the 1986 to 1988 time period is really the direct cost of the hardware and the additional support costs over and above the cost that is necessary to sustain the shuttle capability to meet the requirements of the Government, of NASA, and the DOD primarily. That cost includes a charge for the external tank that are expended in the mission, a charge for refurbishing the solid rocket boosters that are recovered, the cost of recycling the orbiters and crew equipment, the propellants, the spares that are used, an allowance for engine overhaul, and spare parts. It includes the launch, the additive cost for the launch and mission operations but it does not include the cost of the basic capability because that capability is required for Government purposes. It does, in fact, probably reduce somewhat the cost to the Government of maintaining that capability, because you can begin to realize the benefits of learning as you launch more missions and as you combine payloads.

Mr. TORRICELLI. So that is the total of all factors, all elements considered in reaching that price?

Mr. NEWMAN. I believe I have mentioned the primary factors. But, the intent is that it is those costs, over and above the basic capability cost of sustaining the shuttle and the necessary crews and other activities to support the Government requirements.

Mr. TORRICELLI. The second question I have, Mr. Chairman, is: Is there now, or is there an intention to have in the future, a financing capability aimed at expanding the number of customers that can use the shuttle flights? A financing arm of the service. I assume this is all being done now on a cash basis for companies that want to use the service.

Mr. NEWMAN. The customer who requests a service is given a payment schedule. He pays over 33 months prior to launch, on a

schedule that approximates the pattern in which the costs-per-launch are incurred. So, he does have to pay prior to the launch, and then there is a final settlement after launch.

Mr. TORRICELLI. So that at the time of launch, the entire cost has been paid?

Mr. NEWMAN. The entire charge for that mission, yes. Most customers use only a part of a shuttle, so his portion is computed on the basis of the size and weight of his payload.

Mr. TORRICELLI. Are you looking at, or do you consider it necessary to look at longer term, ways to make the service both competitive and available to a different range of customer, such as by making financing available beyond the date of launch?

Mr. NEWMAN. We do not have the kind of authority that would permit us to make a loan to the customer. We do work on foreign missions somewhat with the Export-Import Bank, and there has been some assistance in that respect.

Mr. TORRICELLI. Thank you, Mr. Chairman.

Mr. VOLKMER. The Chair now recognizes the gentleman from New York, Mr. Carney.

Mr. CARNEY. Thank you, Mr. Chairman.

Mr. Newman, I was just wondering, as long as they were talking about financing, do you think I could use this Mastercard and put my wife into geosynchronous orbit?

Mr. NEWMAN. It might be hard to get her back, sir.

Mr. CARNEY. Mr. Newman, I realize you are the comptroller and not a scientist, however, we got on a very important topic here. The gentleman from Florida brings up what I consider to be one of the most important topics today with your agency, and that is the competition between the French consortium, the European consortium, and the United States for this. I only have a couple of questions in that area, and then I am going to go back to the dollars and cents.

There is not space available, to my knowledge, on any of our shuttle flights scheduled through 1986 even if one were to want to get on one. Is that correct?

Mr. NEWMAN. There are now some vacancies. The missions scheduled through 1986 are essentially full—there are payloads on all the missions, except for provisions for reflights. In other words, there are some missions that are only partially filled and could accommodate an additional payload of the proper size.

Mr. CARNEY. Is that because we had scheduled someone and they then made a decision not to go forward with it, or is that because the space had never been rented?

Mr. NEWMAN. It takes a nonrefundable deposit of $100,000 to reserve space. There have been some customers who have deposited that $100,000 but have later decided to go on other vehicles. So there are a few open spots in the shuttle flight plan for the next few years, but in terms of spots into which a payload could fit, not total shuttle missions.

Mr. CARNEY. Thank you. For the record, my colleague from Florida said that the last Ariane flight exploded. Actually, it went into aquasynchronous orbit in the Atlantic Ocean. Now getting back to bean counting, if I may. The Agency traditionally has done a lot of work with the Department of Defense. Along those lines, we might

- Space applications
  - Environmental observations technology (atmospheric science, experiment development, space/ground/aircraft investigation
- Space station technology development

LEWIS RESEARCH CENTER

- Aeronautics research and technology
  - Aero propulsion systems, engine component technology, engine systems research
  - Internal computational fluid dynamics, unsteady aerodynamics, and aeroelasticity
  - Materials and structures
- Space research and technology
  - Chemical and electric propulsion
  - Space energy conversion; power generation
  - Space data and communications
  - Materials and structures
- Space applications
  - Space communications research; Advanced Communications Technology Satellite development
- STS/Centaur development and operation
- Atlas/Centaur launch vehicle management
- Space station technology development

MARSHALL SPACE FLIGHT CENTER

- Space Shuttle main engine, external tank, and solid rocket booster development and procurement
- Development of NASA elements of Spacelab (crew transfer tunnel, hardware mock-ups, crew trainer, etc.) and procurement of Spacelab hardware from ESA
- Intertial upper stage support for non-DOD missions
- Space Telescope project management
- Materials-processing-in-space research and development
- Spacelab payload mission management for Spacelabs 1, 2, and 3
- Advanced concept studies for manned space flight, including space station

NATIONAL SPACE TECHNOLOGY LABORATORIES

- Acceptance testing of the Shuttle main engines
- Shuttle main propulsion test article development testing
- Remote sensing and environmental research
- Support of co-located tenant organizations

be seeing this year some moneys coming over that would not be in your budget but rather in the DOD budget. An example that comes to my mind is the X-29 program, which is, I believe, funded by DARPA, if I am not mistaken. But that forward sweptwing program is being run by NASA and contracted out through NASA. It is a DOD program. How many programs of that nature might you be doing in fiscal year 1984, and what kind of impact will that have on your budget?

Mr. NEWMAN. The Department of Defense reimburses NASA for shuttle missions and the reimbursements that we are anticipating are on the order of $75 to $80 million in 1984. They also reimburse us for procurement of a substantial amount of hardware in the shuttle program for their development of the Vandenburg Air Force Base launch site, and at some of the other control centers that they have. The reimbursements in that area are in the order of a couple of hundred million.

Mr. CARNEY. From an accountant's standpoint, would that reimbursement mean that your agency is going to spend more than the $7,106 million, or is that included in there?

Mr. NEWMAN. It is not included in that figure. Now, if it is from the Department of Defense, it is included in their appropriations and they justify it.

Much of this hardware that we buy for them really is hardware that could be bought either way—they could buy it direct or they could buy it through us. They use us as a procuring agent because we are buying similar hardware for our own requirements.

Mr. CARNEY. Correct. Aside from not buying hardware but in the area of research and technology and development; isn't there also an infusion of moneys from other Federal agencies, specifically DOD, for programs. The X-29 for instance?

Mr. NEWMAN. Yes, and there is a good deal of funding that we receive from the private sector.

Mr. CARNEY. Do we have an accounting of that type of money? Is that over and above—and I ask that question again in the R&T and R&D instance—is that over and above the $7,106 million?

Mr. NEWMAN. It is.

Mr. CARNEY. Can you give me a rough estimation as to how much NASA will then spend?

Mr. NEWMAN. Yes. There is, incidentally, in the front part of the budget book, a summary of this for each appropriation. The total is on the order of $1 billion that we estimate in fiscal year 1984 for research and development. It depends very much on actions by the other agencies, but the major elements of that are about $200 million in the space shuttle program that is based on buying hardware and equipment, the nonrecurring type costs for the Department of Defense. There is, for shuttle operations, about $260 million in total, of which $75 to $80 million is for the Department of Defense. There is for expendable launch vehicles something on the order of $180 million, some of which comes from the private sector, as did some of that shuttle operations money.

In the applications area, we are buying meteorological satellites for NOAA, the weather satellites, and they do reimburse us for that. There is a whole series of items of that type.

Mr. CARNEY. We are looking at a program of $8 billion now, the NASA program?

Mr. NEWMAN. You are looking at funding handled by NASA on the order of $8 billion. Many of those things, though, I would not call NASA programs. We would not do them as part of the program for which NASA is responsible.

Mr. CARNEY. I understand, but NASA will be involved, people will be working, and we will be utilizing the great expertise of the Agency. It is a positive atmosphere, you might say, for your Agency that we are getting additional moneys in and you can go forward with these programs. If I may, with very limited time here, I would like to go to one other thing, and that is that for the last couple of years we have had budget constraints within the Agency. Basically what we have done is cut back in personnel through attrition, and that has led to our people becoming stale. We are not bringing new, young, exciting people into the Agency. Now in 1984, we should have some relief on that.

I am not saying that the people in the Agency are not doing a great job. Do not misunderstand me. But for 3 or 4 years, we have not had the ability to bring in new people. Now, in 1984, it is my belief there will be some relief in that area. Can you give me an idea of what type of numbers we would be talking about when it comes to dollars and personnel that we might be able to see?

Mr. NEWMAN. We have made a very deliberate decision. In fact, we have been able to start on it some this year. We have had a downward trend in personnel over a number of years, and we have not been able to hire the recent graduates we would like to hire. This year and again next year, we are making an effort to hire considerably larger numbers of recent graduates. I think, we are talking in terms of about 370 this year and about 450 as our target for next year. These would be recent college graduates to replace the attrition that we have in the older people.

Mr. CARNEY. Thank you very much. The bell has rung, and I yield back the time remaining that I do not have to the Chair.

Mr. VOLKMER. I will thank the gentleman.

The gentleman from California, Mr. Dymally.

Mr. DYMALLY. I pass.

Mr. VOLKMER. Then we have Mr. Chandler, from Washington.

Mr. CHANDLER. Thank you, Mr. Chairman.

Later today and this week, this committee and also Education and Labor will be dealing with helping to develop scientific and technical minds. There are a variety of means to do that. One idea that has occurred to me is that we might well utilize agencies like NASA as a workstudy experience for young people who are coming along. What I would be interested in knowing is, do you feel that the Agency would be able to provide a meaningful work learning experience for young people, perhaps late high school or college age, and would they in turn be useful to NASA if they were made available to NASA under a program like that?

Mr. NEWMAN. The answer is yes, sir. We do have a number of programs already going to do just that sort of thing. We do have a co-op program for students primarily on the undergraduate level. We do have summer fellowships for both faculty and graduate stu-

dents at the NASA centers. We do have graduate student researchers. So we are working in that area.

Mr. CHANDLER. How extensive is the program that exists now?

Mr. NEWMAN. We have about $2 million in summer faculty fellowships. The graduate student researchers support is about $1.4 million. As for co-ops, we have about 1,100 people in the program or rotating assignments, so we have a fairly large number of people involved.

Mr. CHANDLER. I did not mean to put you on the defensive. What I am seeking here is whether you could handle more.

Mr. NEWMAN. The answer would be yes. As I was pointing out, we do have it going now; but, we could fit more into the effort that we already have in process and with some reasonable experience.

Mr. CHANDLER. Are any of those people that you are utilizing now persons who are active in the teaching profession?

Mr. NEWMAN. We do have the summer faculty fellowships which are, in fact, college professors. I am not aware of any large number of high school teachers that we have involved, although I think we have some short-term training programs for them but not in the regular work experience.

Mr. CHANDLER. Thank you, Mr. Chairman. I have no further questions.

Mr. VOLKMER. The Chair now recognizes the gentleman from Pennsylvania, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

If Congress, in its wisdom, were to decide to freeze the aggregate budget for NASA at 1983 authorization levels—or, better yet, appropriations levels, what you are actually spending right now—how difficult would it be for NASA to live within such a budget?

Mr. NEWMAN. It would be very disappointing, and it would give us some serious problems. One of the things we have been able to do this year is to introduce some new initiatives, the Venus radar mapper, the numerical aerodynamic simulation and the advanced communication satellite. Such a cut would make it virtually impossible to conduct those new initiatives.

Mr. WALKER. There would be no way that you could take lower priority items and still go ahead with some of your new initiatives if you had room within an aggregate?

Mr. NEWMAN. At the appropriations level, you are taking about $300 million out of the program. I think we would feel committed to go ahead with the things we have already approved and invested in heavily. We would have a problem of balancing the impact on the shuttle flight rate against new initiatives in the science area, but I think it would be difficult to get that kind of money out without really doing a fair amount of damage to the momentum we have been building in the science and aeronautics area.

Mr. WALKER. Under a freeze kind of philosophy then, in your opinion the essential difference between a freeze budget and the budget that you have presented would be that the new initiatives probably would be struck. Is that a fair generalization of what you just said?

Mr. NEWMAN. That would not do it. We would still have to make cutbacks in the ongoing areas. I think we would try to preserve and meet our major commitments in those projects where we have

invested a good deal of money. I think we would have to make a cutback in the shuttle operations area, in addition, to get that kind of money out.

Mr. WALKER. We are talking, you say, about a $300 million difference?

Mr. NEWMAN. Yes; our budget in fiscal year 1983 is $6.8 billion. The request for 1984 is $7.1 billion. So that it is about $300 million.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you very much.

Mr. Bateman.

Mr. BATEMAN. Thank you, Mr. Chairman.

Mr. Newman, in your written statement on page 6, I notice some figures there which intrigue me somewhat, and I would like to inquire about them. In particular, under the heading Subsonic Aircraft Systems, I note that for the laminar flow control research program, appropriations or authorizations have been running at $8 million in fiscal year 1982, $3 million in 1983, and nothing in fiscal year 1984. It is my understanding that this research program has been very promising in the ultimate results that were expected from it, and that the fruition of those expenditures in earlier years would arrive in 1984, if it were continued to be funded. I note that, alas, there is no funding for fiscal year 1984. Could you comment on the absence of anything to continue the program to its fruition?

Mr. NEWMAN. Of course, Dr. Kerrebrock will be testifying on the aeronautics program on Thursday. But, my understanding is that with the 1983 funding and with the funding that is in the system, they will be able to deliver test sections and to test those sections and to conduct experiments with those sections. Of course, most of that work is at the Langley Research Center.

Mr. BATEMAN. Indeed it is.

Mr. NEWMAN. They will get sections from both Douglas and Lockheed.

Mr. BATEMAN. My understanding is that they have undergone testing in the wind tunnel environment with a great deal of enthusiasm as to the potential that has been shown. But the funding for fiscal year 1984 would have seen it through to actual testing in the air. Perhaps this is something that I could well reserve the right to submit in written questions.

Mr. NEWMAN. Yes, sir, I think that is appropriate. I do not remember any real airborne testing, unless it was of small sections.

Mr. BATEMAN. I think the contemplation was to move from the wind tunnel to airborne testing, provided the funds were there for it.

The other inquiry, Mr. Chairman, might also be addressed through specific written inquiries because it may not be an area where you have technical or specific familiarity. That is the advanced transport operating systems project, which again I will tell you is another Langley Research Center activity, and which again I am advised by my informants that it shows a great deal of promise. It is, again, a program which would have been expected to be completed during fiscal year 1984 if continued, but I observe no funds for its continuation.

Let me, if I may, just make known for the record the expression of interest in this regard and a desire for more specific information at a later hearing or by submitting questions for the record.

One last question. I have been asked to inquire, with regard to NASA as a joint participant with the Department of Energy in the space reactor program. The inquiry is: Where is that carried in the NASA budget, and what is the fiscal year 1984 request for this program?

Mr. NEWMAN. The funding is in the line titled: "Space Research and Technology." The dollar amount for 1984 is $3.9 million. It would be in that area of the budget.

Mr. BATEMAN. Thank you, Mr. Chairman.

Mr. VOLKMER. I would like to have a couple of questions, and then we will proceed to the next witness.

On the question of the budget as to the reimbursables. So that I get it in my own mind and get it straight, you project that you will be receiving reimbursables for 1984 estimated capability development of $211.5 million and in operations $473.4 million. Is that built into the budget? I am trying to figure out where this appears in your budget.

Mr. NEWMAN. That does not appear in the NASA request for appropriations.

Mr. VOLKMER. I understand that.

Mr. NEWMAN. There is in the front of the book a summary of the amount. There also is in the President's budget book a summary of those amounts. It is built into our planning and, in fact, we reduce the requirements of NASA for appropriated funds.

Mr. VOLKMER. Where can I find where that money goes and into what areas. In capability development, is some of that going into operations at Kennedy or Huntsville or Goddard? Where is this money actually going?

Mr. NEWMAN. We can provide you backup for that, but let me give you some examples. The reason I am answering the way I am, much of this is for things we would not do ourselves. We do it only because of the requests of the reimbursing user, and we act as a procuring agent.

Mr. VOLKMER. So it is going to the contractors.

Mr. NEWMAN. Yes.

Mr. VOLKMER. I can understand that. If it does, I would like to know that.

Mr. NEWMAN. The money for shuttle operations is applied to the total requirements for shuttle operations. We in effect merge that and buy fuel tanks and other requirements for the shuttle operations and charge the user a fixed price to provide him the services. For expendable launch vehicles, it is kind of the same thing. We apply that money to buy Delta or Atlas Centaur launch vehicles and to fund the launch operations contract; and we charge the user a price for launching his payload.

Mr. VOLKMER. Can you give me for the record a breakdown of where the reimbursables are going to be allocated?

Mr. NEWMAN. Yes, sir.

[The information follows:]

NASA Reimbursements

Under appropriate conditions, NASA acts as the procurement agent for other Government agencies, and provides services and miscellaneous support to Government and non-Government organizations, on a reimbursement basis. The financing of these reimbursable activities is not included in the NASA requests for direct appropriations, but rather is reflected in the various NASA budget schedules as reimbursable orders. Thus the actual funding for the reimbursements is carried in the appropriation requests of the ordering agencies, or is provided by commercial or foreign organizations.

The major programmatic areas of reimbursable activity are the Space Transportation System (Department of Defense and commercial users), Space Applications (procurement of weather satellites for NOAA), and Energy Technology (research and technology contracts for DOE).

For purposes of budgetary consideration, there are two basic types of reimbursements: (1) those activities in which NASA's primary role is that of procurement agent/monitor, and (2) those activities in which NASA serves as the manager of a coordinated program in which NASA's requirements are closely integrated with those of the other agencies/users. In the former category, major changes in the anticipated level of reimbursable orders received by NASA usually will have little impact on NASA direct fund requirements. On the other hand, significant deviations in actual orders received in the latter category can have major repercussions on NASA's requirements for direct (appropriated) funds. This, of course, is because the funding plan assumes a sharing by NASA and the other parties of fixed costs and of the economies of scale. While every effort is made to anticipate and provide for reasonable estimates of reimbursements at the time of budget preparation, experience has shown that sizable variances in actual orders received can occur as the program unfolds. NASA has essentially no control over changes in the programs and budgets of other agencies, or in the business decisions made by commercial and foreign organizations.

The table below shows NASA estimates of reimbursable orders by major program category, as reflected in the fiscal year 1984 budget.

NASA reimbursable activities—fiscal year 1984

[Millions of dollars]

	Fiscal year 1984 estimate
Research and development:	
Space transportation capability (hardware procurement and support)	$211
Space transportation operations:	
Shuttle	264
Expendable launch vehicles	180
Applications programs (meteorological satellite procurement and other activities)	115
Technology utilization	14
Aeronautical research and technology	25
Energy technology	98
Tracking and data acquisition	21
Total research and development	928
Construction of facilities	7
Research and program management	50
Total NASA	985

Reimbursable activities are carried out at all NASA field centers. Most of the funding goes into contracts for the procurement of equipment and services required by the ordering organization; some of the funding is applied to joint research projects. Examples include:

Goddard Space Flight Center—reimbursable orders for Delta launch services and meteorological satellites;

Lewis Research Center—Centaur launch services, energy tasks, and aeronautics projects;

Ames Research Center—aeronautics activities;

Marshall Space Flight Center—procurement of Space Shuttle external tanks and Spacelab equipment;

Kennedy Space Center—STS launch and landing activities, and procurement of Space Shuttle ground support equipment for Vandenberg Air Force Base.

Mr. VOLKMER. I would appreciate that. The other thing I would like to ask about concerns the question from Mr. Walker. In your budget, you have determined the impact of inflation, have you not?

Mr. NEWMAN. We have provided in the case of the contractor effort for an estimated growth in price estimates from now until the 1984 period, yes, sir, if that is the question you are asking. We have provided for some inflation.

Mr. VOLKMER. What I would like to get to is, the inflation figure that is used basically on your program is not the same as inflation figures used in general government, like the CPI or anything else; is that correct?

Mr. NEWMAN. That is generally correct. In that we develop forward pricing rates at the contractors. Of course, we have a negotiation process in the development of the budget, but I think you could say that whereas the President's projection of the GNP deflator is 5 percent for fiscal year 1984, we are using rates that are somewhat higher than that, like 6 or 7 percent, depending on the area. If you take utilities, we are projecting a larger increase. In our major contractors, we are basing it on rates like 6 to 7 percent.

Mr. VOLKMER. That is already figured into your 1984 budget?

Mr. NEWMAN. Those are incorporated into the estimates we are giving you, yes, sir.

Mr. VOLKMER. But the budget actually is about 4 percent in reality?

Mr. NEWMAN. The budget is up 4 percent from the level appropriated in fiscal year 1983.

Mr. VOLKMER. Which does not cover the total, if you take the 1983 plus your inflationary GNP deflator; is that correct?

Mr. NEWMAN. That is correct. If you take the trend over several years, we are essentially breaking even with inflation. If you take the trend from fiscal year 1983 to fiscal year 1984, we are up 4 percent. The inflation we expect to encounter is somewhat above that, so there is some decrease in the real effort.

Mr. VOLKMER. I have one final area. I notice that on the moneys that were reprogramed, the letters were sent, where did that money come from?

Mr. NEWMAN. Of course, it all was within the appropriated amount.

Mr. VOLKMER. I realize that. Did it come from the money Congress thought they were appropriating to start up a fifth orbiter?

Mr. NEWMAN. The authorization, as you know, included $85 million for a fifth orbiter. The appropriations we got did not make specific provisions for a fifth orbiter. We did program about $20 million into spares, which we identified as being usable for a fifth orbiter but also usable for a four-orbiter fleet, and we made that adjustment in our plan for fiscal year 1983.

Mr. VOLKMER. How much was that?

Mr. NEWMAN. About $20 million.

Now we also had good experience in the flight test program of the shuttle which enabled us to reduce the shuttle funding somewhat. We found that we had to cover increases in expendable launch vehicles because of the shift in the reimbursement situation. We found that we had to apply some additional funding in the operations area.

Mr. VOLKMER. Thank you very much. I appreciate your testimony here today.

Mr. LUJAN. Mr. Chairman, I have one more question.

Mr. VOLKMER. I recognize the gentleman from New Mexico, but we still have three more witnesses.

Mr. LUJAN. Just one basic question, because I look at the overall budget projections, and the deficit for 1984 at $208 billion. It is the most discouraging chart that you have ever seen. We all love NASA—that is why we happen to be on this committee. As you can see, the entire committee hearing is rather a love-in. We are all for space transportation and aeronautical research and all the different good things that you do.

I would like to identify some items that we could cut out that would not be particularly harmful to the overall program. Maybe the spare parts portion, the fifth orbiter which NASA really did not want but provided some jobs out there somewhere, some of those other items. Maybe that is not quite a fair question at this point, or maybe you would like to comment on it.

Mr. NEWMAN. We think we have a solid budget.

Mr. LUJAN. Everybody does. I have never been at a hearing where anyone does not think that this is a bare-bones budget. We really have to look at those things, and we will be looking in the entire Federal budget for cuts. If we are going to be consistent with opposing a $208 billion deficit, you have to do it some place, and that is the reason for my probing. Where are some of the items within NASA that we could realistically cut without gutting the whole program. It might make it too lean for comfortability.

Mr. NELSON. Will the gentleman yield?

Mr. LUJAN. Sure.

Mr. NELSON. One of the items that was not in NASA's last year budget was the solar maximum mission. Is that in the budget this year?

Mr. NEWMAN. Yes, it is in the budget.

Mr. NELSON. You might want to ask then, if it was not there last year, and NASA did not want it, much to the consternation of a number of members of this committee, why is it suddenly there this year?

Mr. NEWMAN. It was in the 1982 column of the budget plan. I am trying to draw on my memory. There was a change in the budget plan. We did originally want to conduct that mission and we do have work underway to do it, and funding is included in this budget for the solar maximum mission.

I wonder if I could respond to Mr. Lujan's question a little. We have a budget, as was pointed out, that does not provide quite the same level of effort in 1984 as in 1983. Within that budget, we have introduced a few new initiatives. Our program is of a nature where you complete a project and unless you initiate something to follow on, then eventually you do not build on what has been accomplished. You do need to undertake new initiatives.

In the aeronautics area, we have been pushed rather hard to get moving on that area, and we do have an increase from $280 to $300 million, I think a fairly modest increase, and we do have a very important initiative in that area that can have a very important

impact on the computer capabilities of the country as well as the aeronautical capabilities.

The funding for the spares in the shuttle program is really to support a confident operation of the four-orbiter fleet, and we do think that is an excellent decision to include that funding in the budget.

Mr. LUJAN. Is it not a flexible one, though, to be able to do the repairs or could it be used for the fifth orbiter? There seems to be some leeway in it.

Mr. NEWMAN. The absence of that amount in there would make it much more difficult to resume production on a fifth orbiter than it would be if we do go ahead and fund those spares to keep the contractors involved in operations during that period. In that sense, it would make a fifth orbiter decision easier and more feasible if a decision were made in the future.

Mr. LUJAN. But NASA has not always been very keen on the fifth orbiter; is that correct? Let me say it right out. It is the contractors that want to build a fifth orbiter, not necessarily NASA.

Mr. NEWMAN. In the original shuttle program, the plan was five orbiters. There has been a great deal of discussion about the requirement. A decision was made to cut back to four, but there was always an option to build additional orbiters as the need developed. What you have here is really preserving our capability to exercise that option, at the same time providing equipment and spares that would be highly desirable to have to give you confidence in operating a four-orbiter fleet.

Mr. LUJAN. Have we had that much use in Columbia for spare parts so that if you multiplied it by four you would come to this figure for spare parts? Or is that not the case because it is too new?

Mr. NEWMAN. I do not think we have enough experience really to answer that question. There are a lot of the spares used. One of the examples right now is the change-out of engines on the orbiter for the next flight, which is either completed now or taking place right now.

Mr. LUJAN. I think it is very difficult at this point for you to give me a lot of places where we may be able to reduce expenditures.

Mr. VOLKMER. Thank you very much, Mr. Newman.

Our next witness is Billie J. McGarvey, Director of Facilities, NASA.

We have copies of your prepared statement, and it will be made a part of the record. If you wish, you can summarize it. Or if you wish to read your full statement, you may do that.

[A biographical sketch of Mr. McGarvey follows:]

BILLIE J. MCGARVEY

Billie J. McGarvey was appointed Director of Facilities on October 31, 1978.

Born on August 11, 1923, in Fort Worth, Texas, he attended Texas Technological University and the University of Colorado. He was awarded Bachelor of Science and Master of Science degrees in civil engineering by the University of Colorado. During World War II, he served as a combat pilot, a flying instructor, and an engineering test pilot in the Air Force.

He subsequently served in a series of responsible civil engineering assignments in Scotland, England, United States, Japan, and Hawaii. His principal assignments in the Air Force included the Deputy Chief of Staff for Civil Engineering of the Air Force Logistics Command, Deputy Chief of Staff for Civil Engineering of the Pacific Air Forces, and the Director of Civil Engineering for the United States Air Force.

He was the Assistant Deputy Chief of Staff for Programs and Resources at Headquarters USAF when he retired as a major general in 1978.

Decorations and awards include the Air Force Distinguished Service Medal, Legion of Merits, Distinguished Flying Cross, Air Medals, Air Force Commendation Medals, and the NASA Exceptional Service Medal. He is a registered professional engineer in Texas.

He is married to the former Virginia Stephens of Modesto, California.

STATEMENT OF BILLIE J. McGARVEY, DIRECTOR OF FACILITIES, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY RICHARD IRWIN, DEPUTY DIRECTOR OF FACILITIES, NASA

General McGARVEY. Mr. Chairman and members of the subcommittee, I appreciate this opportunity to appear before you today to present the NASA fiscal year 1984 construction of facilities budget request. Our request totals $150.5 million, as compared to $100 million authorized in fiscal year 1983 and $97.5 million that was appropriated. The construction of facilities program is vital to maintaining reliable and responsive institutional capabilities of the agency. It provides for the necessary repairs, rehabilitation, and modification of existing facilities, construction of new facilities, and facility planning and design activities which support the research, development, and testing activities of the agency.

The NASA physical plant, comprised of unique aerospace research, development, and test facilities and equipment, is a key ingredient in carrying out our basic mission. This fiscal year 1984 request has been structured to meet our continuing objective of preserving and enhancing the capabilities and usefulness of that physical plant. The budget request is a lean but balanced response to needs for supporting increasing shuttle flight rates, improving shuttle manufacturing and processing efficiencies, providing modest enhancements of existing facilities for improved research and testing capabilities, and repairing and preserving the physical plant. In highlighting the salient features of the budget request, I will briefly discuss several of the large, discrete projects and then summarize the minor program and planning and design activities.

An area of continuing interest for this committee has been the performance of shuttle launch facilities at the Kennedy Space Center. I am pleased to report that the facilities supporting the first five STS launches have performed very satisfactorily and have suffered very little damage. We are particularly pleased that repair or renovation of the launch facilities have not been pacing items affecting turnaround activities between shuttle flights.

We are requesting $53.3 million for space shuttle and shuttle payload facilities, with the major projects located at the Kennedy Space Center and the Michoud Assembly Facility. Facility modifications to mobile launch platform No. 3 at Kennedy, estimated to cost $27.3 million, are required to support increased flight rates from KSC in 1986 and beyond. Experience from the first five flights has shown that our earlier estimates of the mobile launch platform support were too optimistic. Current assessments based on this experience indicate that the expected launch rate per mobile launch platform will be eight flights per year. This necessitates the modification and the activation of a third mobile launch platform to support the scheduled flight rates for fiscal year 1986 and beyond.

A second major project at the Kennedy Space Center, estimated to cost $9 million, is the construction of a cargo hazardous servicing facility which is required for the safe processing of large vertical class payloads. This project will provide the necessary hazardous servicing capability for hypergols, propellant loading and draining, ordinance system installation, testing and checkout. Existing facilities are too small to service the large vertical payloads and do not have the capacity to accommodate the planned cargo throughput.

Additional facility modifications are also required at the Michoud Assembly Facility in New Orleans, in the amount of $11.7 million, to support production rates of 24 external tanks per year. This project continues work funded in fiscal year 1983 and prior years to provide the necessary capability for the fabrication, assembly, testing and checkout, and application of thermal protection systems for external tanks. The facility work includes major modifications in the main manufacturing building to improve production flows and increase the capacity for applying sprayed-on foam insulation to the external components. Also included are modifications to building 303 that are necessary to provide an external tank X-ray, rework, and staging facility. The storage capacity for demineralized water will also be increased by adding a new 500,000-gallon storage tank.

One other critical project included in this budget request that is required to support the space shuttle operations is the modifications for additional chillers for the mission control center at the Johnson Space Center in Houston in the amount of $2.3 million. This project will provide additional chiller capacity and backup for the mission control center. This is needed to insure adequate support for increased flight rates which will require simultaneous operation of two flight control rooms. The project is vital to supporting the flight operations at the Johnson Space Center.

To enhance the utilization of our unique NASA aeronautical facilities, a total of $24 million is being requested for aeronautics and space technology projects. One of the critical requirements is the need for an adequate facility for basic fluid mechanics, aerodynamics, and nonintrusive diagnostic research at the Ames Research Center in northern California. The construction of a fluid mechanics laboratory, in the amount of $3.9 million, is included in the budget request for this purpose. The facility will house four small research wind tunnels, a laser laboratory for nonintrusive diagnostics, and necessary equipment and support space.

Another key research and development facility included in this request is a composite materials laboratory, estimated to cost $5.1 million, at the Langley Research Center in Virginia. The necessary modifications and an addition to an existing building will provide an advance composite materials processing laboratory for polymer research and improved composite matrix materials for aircraft and space structures application.

One other major project at Langley included in this budget request is the modifications to the 30- by 60-foot subsonic wind tunnel, estimated to cost $4.4 million. This unique tunnel is heavily utilized to explore low-speed flight characteristics of highly maneuverable aircraft and features a unique free-flight testing capability,

as well as conventional model support testing. Turntable and model support systems require extensive repair and upgrading to provide improved accuracy of data, reliability, productivity, model weight capabilities, and safety. Productivity of the tunnel will be increased approximately 25 percent by these modifications.

Another major aeronautical test facility project is the modifications for small engine component testing at the Lewis Research Center in Cleveland, in the amount of $7 million. Major modifications within the engine research building are required to provide research capability for small gas turbine engine components to provide improved performance and fuel economies. The project will provide a compressor test facility for axial, centrifugal, or mixed-flow compressors. It will also provide a turbine test facility, complete with drive systems and related mechanical and control systems.

Modifications to the icing research tunnel at the Lewis Research Center, at an estimated cost of $3.6 million, are also required to provide a wider range of test conditions, more precise control, and more efficient operations in meeting the increased needs for icing research for rotorcraft, general aviation, military, and commercial aircraft. Achieving increased reliability is an added benefit of this project.

A $2.7 million project at the Jet Propulsion Laboratory, in Pasadena, Calif., is required to construct a frequency standards laboratory for developing, testing, repairing, and calibrating intractable frequency standards. This laboratory is essential for providing needed improved precision and added capabilities for advanced navigation techniques, such as the very long baseline interferometry navigation system which will support the Galileo probe mission.

A $1.7 million project is also included in the budget request to relocate a 26-meter antenna in Spain. The relocation is required to provide support for spacecraft in highly elliptical Earth orbits, space shuttle backup, and TDRSS backup. The relocation to the main deep space network complex near Madrid will permit the closing of the space flight tracking and data network station in Spain and realize operational savings of approximately $2.5 million annually.

In moving to the minor facility projects, completing our budget request is $48.8 million for repair, rehabilitation and modifications, and minor construction projects, and $9.2 million for facility planning and design.

Repair of facilities, not in excess of $500,000 per project, totals $19.5 million. The repair program provides a means of restoring our facilities to their originally intended and designed capability. These projects were distilled from over $30 million of priority items and help provide the principal "lifeblood" capabilities for preserving the physical plant in a reliable and responsive mode.

$24.5 million is requested for rehabilitation and modification projects under $500,000 per project. This is a crucial program for protecting, preserving, and enhancing the capabilities of facilities so that they can accomplish the NASA mission in a more efficient, safe, and economical manner. These projects are high priority

items which were selected from total requests that exceeded $35 million.

The third element of the minor program is the minor construction projects not in excess of $250,000 each. These projects total $4.8 million and consist of new construction and additions to existing facilities to improve the usefulness of our physical plant in response to changes in utilization and adaptations required by changes in technology or mission needs.

Finally, we are requesting $9.2 million to conduct the necessary advanced planning and design for facilities activities. Typical of these requirements are the preliminary engineering reports, cost estimates, scheduling, final design, site investigations, engineering studies, and installation master plans.

In summary, Mr. Chairman, this $150.5 million budget request for NASA facilities work in fiscal year 1984 is a balanced but modest program which addresses our most urgent facility requirements for carrying out the principal research, development, and testing activities of the agency and provides for the most essential repair and rehabilitation needs.

We sincerely appreciate your support of our facilities program in the past and request your favorable consideration of this fiscal year 1984 budget request.

[The prepared statement, plus answers to questions asked of General McGarvey, follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

STATEMENT

OF

BILLIE J. McGARVEY
DIRECTOR OF FACILITIES

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS, AND
SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS
COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

Messrs. Chairmen and Members of the Subcommittees:

I appreciate this opportunity to appear before you today to present the NASA FY 1984 Construction of Facilities (CoF) Budget request. Our budget request totals $150.5 million as compared to $100 million authorized in FY 1983 and $97.5 million that was appropriated. The CoF program is vital to maintaining reliable and responsive institutional capabilities of the Agency. It provides for the necessary repairs, rehabilitation nd modification of existing facilities, construction of new facilities, and facility planning and design activities which support the research, development, and testing activities of the Agency.

The NASA physical plant, comprised of unique aerospace research, development, and test facilities and equipment, is a key ingredient in carrying out our basic mission. This FY 1984 CoF budget request has been structured to meet our continuing objective of preserving and enhancing the capabilities and usefulness of that physical plant. The budget request is a lean but balanced response to needs for supporting increasing Shuttle flight rates, improving Shuttle manufacturing and processing efficiencies, providing modest enhancements of existing facilities for improved research and testing capabilities, and repairing and preserving our physical plant. In highlighting the salient features of the budget request, I will briefly discuss several of the large, discrete projects and then summarize the minor program and planning and design activities.

An area of continuing interest for this committee has been the performance of Shuttle launch facilities at the Kennedy Space Center. I am pleased to report that the facilities supporting the first five STS launches have performed very satisfactorily and have suffered very little

damage. We are particularly pleased that repair or renovation of the launch facilities have not been pacing items affecting turnaround activities between Shuttle flights.

Space Transportation Systems

We are requesting $53,300,000 for Space Shuttle and Shuttle Payload facilities with the major projects located at the Kennedy Space Center (KSC) and the Michoud Assembly Facility (MAF). Facility modifications to Mobile Launch Platform (MLP) #3 at KSC, estimated to cost $27,300,000, are required to support increased flight rates from KSC in 1986 and beyond. Experience from the first five flights has shown that our earlier estimates of MLP support were too optimistic. Current assessments based on this experience indicate that the expected launch rate per MLP will be eight flights per year. This necessitates the modification and activation of a third MLP to support the scheduled flight rates for FY 1986 and beyond.

A second major project at KSC, estimated to cost $9,000,000, is the construction of a Cargo Hazardous Servicing Facility which is required for the safe processing of large vertical class payloads. This project will provide the necessary hazardous servicing capability for hypergols, propellant loading and draining, ordinance system installation, testing and check-out. Existing facilities are too small to service large vertical payloads and do not have the capacity to accommodate the planned cargo throughput.

Additional facility modifications are required at the Michoud Assembly Facility (MAF) in New Orleans in the amount of $11,700,000 to support production rates of 24 tanks per year. This project continues work funded in FY 1983 and prior years, to provide the necessary capability for the fabrication, assembly, testing and checkout, and application of thermal protection systems (TPS) for external tanks. The facility work includes major modifications in the main manufacturing Building 103 to improve production flows and increase the capacity for applying SOFI to external components. Also included are modifications to Building 303 that are necessary to provide an External Tank X-Ray, rework and staging facility. The storage capacity for demineralized water will also be increased by adding a new 500,000-gallon storage tank.

One other critical project included in this budget request that is required to support the Space Shuttle operations is the Modifications for Additional Chillers for the Mission Control Center at the Johnson Space Center in Houston in the amount of $2,300,000. This project will provide additional chiller capacity and backup for the Mission Control Center. This is needed to ensure adequate support for increased flight rates which will require

simultaneous operation of two control rooms. The project is vital to supporting flight operations at JSC.

Aeronautics and Space Technology

To enhance the utilization of our unique NASA aeronautical facilities, a total of $24,000,000 is requested for Aeronautics and Space Technology projects. One of the critical requirements is the need for an adequate facility for basic fluid mechanics, aerodynamics, and nonintrusive diagnostic research at the Ames Research Center in northern California. The construction of a Fluid Mechanics Laboratory, in the amount of $3,900,000, is included in the budget request for this purpose. The facility will house four small research wind tunnels, a laser laboratory for nonintrusive diagnostics and necessary equipment and support space.

Another key research and development facility included in this request is a Composite Materials Laboratory, estimated to cost $5,100,000, at the Langley Research Center in Virginia. The necessary modifications and an addition to an existing building will provide an advanced composite materials processing laboratory for polymer research and improved composite matrix materials for aircraft and space structures application.

One other major project at Langley included in this budget request is the Modifications to the 30 x 60-Foot Subsonic Wind Tunnel, estimated to cost $4,400,000. This unique tunnel is heavily utilized to explore low speed flight characteristics of highly maneuverable aircraft and features a unique free flight testing capability as well as conventional model support testing. Turntable and model support systems require extensive repair and upgrading to provide improved accuracy of data, reliability, productivity, model weight capability, and safety. Productivity of the tunnel will be increased approximately 25 percent by these modifications.

Another major aeronautical test facility project is Modifications for Small Engine Component Testing at the Lewis Research Center in the amount of $7,000,000. Major modifications within the Engine Research Building are required to provide research capability for small gas turbine engine components to provide improved performance and fuel economy. The project will provide a compressor test facility for axial, centrifugal, or mixed flow compressors. It will also provide a turbine test facility complete with drive systems and related mechanical and control systems.

Modifications to the Icing Research Tunnel at the Lewis Research Center, at an estimated cost of $3,600,000, are required to provide a wider range of test conditions, more precise control, and more efficient operations in meeting increased needs for icing research for rotorcraft, general

aviation, military, and commercial aircraft. Achieving increased reliability is an added benefit of the project.

Other Major Projects

A $2,700,000 project at the Jet Propulsion Laboratory in Pasadena, California, is required to construct a Frequency Standards Laboratory for developing, testing, repairing and calibrating ultrastable frequency standards. This laboratory is essential for providing needed improved precision and added capabilities for advanced navigation techniques such as the Very Long Baseline Interferometry (VLBI) navigation system which will support the Galileo probe mission.

A $1,700,000 project is included in the budget request to Relocate a 26-Meter Antenna in Spain. The relocation is required to provide support for spacecraft in highly elliptical earth orbits, Space Shuttle backup, and TDRSS backup. The relocation to the main Deep Space Network complex near Madrid will permit the closing of the Space Flight Tracking and Data Network station in Spain and realize operational savings of approximately $2,500,000 annually.

Minor Facility Projects

Completing this FY 1984 CoF budget request is $48.80 million for Repair, Rehabilitation and Modifications, Minor Construction, and $9.20 million for Facility Planning and Design.

Repair of Facilities, not in excess of $500,000 per project, totals $19.5 million. The Repair Program provides a means of restoring our facilities to their originally intended and designed capability. These projects were distilled from over $30 million of priority items and help provide principal "life blood" capabilities for preserving the physical plant in a reliable and responsive mode.

$24.5 million is requested for Rehabilitation and Modification projects under $500,000 per project. This is a crucial program for protecting, preserving, and enhancing the capabilities of facilities so that they can accomplish the NASA mission in a more efficient, safe, and economical manner. These projects are high priority items which were selected from total requests exceeding $35 million.

The third element of the Minor Program is the Minor Construction projects not in excess of $250,000 each. These projects total $4.8 million and consist of new construction and additions to improve the usefulness of our physical plant in response to changes in utilization and adaptations required by changes in technology or mission needs.

Finally, we are requesting $9.2 million to conduct the necesary advanced planning and design for Facilities activities. Typical of these requirements are preliminary

engineering reports, cost estimating, scheduling, final design, site investigations, engineering studies, and installation master planning.

Summary

In summary, this $150.5 million budget request for NASA facilities work in FY 1984 is a balanced but modest program which addresses our most urgent facility requirements for carrying out the principal research, development, and testing activities of the Agency and provides for the most essential repair and rehabilitation needs. We sincerely appreciate your support of our facilities program in the past and request your favorable consideration of the FY 1984 CoF budget.

Responses to Written Questions from the Joint House Hearing on February 8, 1983, at which Gen. McGarvey testified.

QUESTION NX-1:

Solid Rocket Booster Refurbishment Facility KSC/Marshall: How does NASA intend to meet a flight rate of 24 flight sets per year without either a new refurbishment facility to accommodate work presently being performed in VAB, or refurbishing existing facilities at Marshall? Why did NASA fail to include a budget request for this purpose in their FY 1984 budget? Does NASA intend to reprogram money for this purpose in the future and if so where will that money come from?

ANSWER NX-1:

Additional facility capacity for Solid Pocket Booster (SRB) refurbishment is required to provide a 24 flight/year capability. Various options are being studied which include: (1) use of the VAB but, modified as needed; (2) modifying and use of other existing facilities at Cape Canaveral Air Force Station, Marshall Space Flight Center, and Kennedy Space Center; (3) new Government-funded facilities at KSC or CCAFS; and, (4) new contractor-funded facilities at CCAFS, KSC, or off-site. Analysis of options, and a procurement plan for recompetition of the booster asssembly refurbishment contract, are scheduled for completion in early March 1983.

A budget request for this facility requirement was not included in the FY 1984 budget because during budget formulation, a contractor-funded facility was under consideration. If the decision is made to provide for Government-funded facilities, it will be necessary to reprogram funds from the R&D account for this purpose.

QUESTION NX-2:

Reimbursement to GSA for property at Ellington Air Force Base: Why must NASA transfer $8.4 million for the purpose of old property which the Air Force has declared surplus? Is this $8.4 million to be used for defense purposes? Would you not feel that such a transfer was bureaucratic?

ANSWER NX-2:

The Property Review Board established in February 1982 by Executive Order 12348 advised all Federal agencies that "...property excessed by a Federal agency should be transferred to another Federal agency only upon payment of the full fair market value of the property..."

The funding in the FY 1984 budget request would implement that provision with regard to the property at Ellington Air Force Base which NASA has occupied since 1961 and has attempted to have

transferred to NASA since 1975. This real property continues to be used for astronaut training and flight proficiency training required for the Space Shuttle program. It is our understanding that GSA will deposit the funds to the general receipts account of the U.S. Treasury. We are not aware of any indication that the $8.4 million would be used for defense purposes.

QUESTION NX-3:

Modifications to Spacecraft Assembly and Encapsulation Facility at KSC: Are these modifications to accommodate DOD payloads and if so why isn't that money in the defense budget?

ANSWER NX-3:

No. These modifications are required to provide safe handling of NASA processed payloads. It is not planned to process DOD payloads through this facility.

QUESTION NX-4:

Construction of Frequency Standards Laboratory, Jet Propulsion Lab: What environmental disturbances are a hydrogen maser sensitive to and if such disturbances include vibration, is JPL the proper location for such a laboratory considering the potential for seismic disturbances?

ANSWER NX-4:

Hydrogen masers are sensitive to disturbances in environmental temperature, barometric pressure, humidity, magnetic field, and to a minor extent, vibration. Temperature variations and magnetic field fluctuations are the environmental factors causing the greatest maser stability problems.

This location is appropriate because this facility will directly support the on-line operations of the Deep Space Network, which is managed at JPL. Also the NASA expertise for development, test, repair and calibration of masers is resident at JPL.

A seismic disturbance will not adversely affect a hydrogen maser unless its magnitude is great enough to cause severe building damage. JPL has been testing masers since the mid-1960's, but little or no test data has been lost because of seismic disturbances. Seismic considerations do not preclude locating this laboratory at JPL where it is needed for upgrading in-line operational support for the masers used by JPL in the Deep Space Network.

QUESTION NX-5:

Modifications to Mobile Launch Platform (MLP)-3: How do the estimated costs for MLP-3 compare to the actual cost for platforms 1 and 2? In what way, if any, will MLP-3 be different than 1 and 2? What is NASA's contracting plan for platform 3; will it be through one contractor or will it be several contractors, and if the later, who will manage those contractors?

ANSWER NX-5:

The estimated cost to modify MLP-3 is substantially the same as the actual costs for MLP's 1 and 2. The costs for MLP-1 were $12,863,255.00 and for MLP-2 were $13,828,685.00. These costs, escalated to the mid-point of the present MLP-3 construction schedule (early 1985), yield an estimate of $22.2M. Added to this amount is approximately $2.9M for additional changes to MLP's 1 and 2 that were requried due to Shuttle operational experience with the first five flights. In addition, a $2.2M MLP park site is included for MLP validation, test and check-out away from the launch pad. There will be no significant differences between MLP-3 and MLP's 1 and 2. Basically, all of these platforms will have the same form, fit and function. MLP-3 modifications will be accomplished through four major efforts, some of which will incorporate multiple work packages. The four are:
-Disassembly and removal of the Launch Unbilical Tower and other non-essential equipment
-Facility and system modifications
-Terminal test and validation contract
-Final validation by Shuttle Processing Contractor

In addition, NASA has awarded an architect-engineer type contract for design, system integration and construction management. Kennedy Space Center has overall management responsibility for design, construction and activation of MLP-3.

QUESTION NX-6:

Rehabilitation and Modification Work: In addition to $19.5 million for general repair work, NASA has requested 65 separate rehabilitation and modification projects totaling $24.5 million for institutional facilities at 12 locations. Is NASA's 5 year planning based on an expansion program, a static program, or a contraction program? What is the basis for the plan? What projects, of the 65, can be deferred?

ANSWER NX-6:

NASA's long range planning is based on maintenance of a strong facilities base needed to meet current research, development and operational requirements. Our earlier rehabilitation, modification, and repair programs funding has proven to be inadequate for maintaining the efficiency and usefulness of NASA facilities and for providing the desired safer environments for personnel. The projects in this request totaling $24,500,000 have

been distilled from approximately $35,000,000 of current essential rehabilitation and modification requirements. Based on relative urgency and cost-effectiveness, the projects in this request are our highest priority requirements. Deferral of this mission-essential work will adversely impact the availability of critical facilities, program schedules, and energy conservation objectives.

QUESTION NX-7:

Michoud Assembly Facility: The budget request includes $495,000 for the repair of the wharf which is used for external tank shipment. How will NASA be able to ship any tanks if the wharf is unusable, which the budget request claims, and the budget request is for FY 1984?

ANSWER NX-7:

Michoud Assembly Facility has two docks (east and west) with one berth for the east dock and two berths for the west dock. Of these three loading positions, only two are usable. The wharf, which extends 130 feet from the east dock, has deteriorated to the point where a barge can no longer be secured to it. This project provides for the replacement of this deteriorated wharf. This third berth is required to support increasing Shuttle flight rates.

QUESTION NX-8:

Construction of Fluid Mechanics Laboratory $3.9 million, Ames Research Center: Compared to previous years, it would seem that ARC is not fully utilized. What other opportunities were investigated to house the proposed wind tunnels? What existing facilities could be used for this purpose? What would be the modification costs?

ANSWER NX-8:

Consideration was given to locating this function in three other ARC buildings; the Hypervelocity Free-Flight Facility, the Electrical Services Building and the Army Research and Technology Laboratory. The cost estimates for initial modifications to these facilities approached the cost of the proposed new facility. Additionally, using these facilities would require the relocation of ongoing R & D and support activities. Also, the final configuration of the existing facilities would have resulted in inefficient use of research equipment. Accordingly, none of these options were considered acceptable.

QUESTION NX-9:

Composite Materials Laboratory, Langley: Modifications and Addition $5.1 million. What is the basis of the $172.80 per square foot estimate for the Laboratory? How does this cost compare with other recent NASA construction work?

ANSWER NX-9:

The current project cost estimate is based on a completed Preliminary Engineering Report by a professional architect/engineering firm. Recent NASA Langley cost experience for similar laboratory type facilities ranges from $144 per square foot to $208 per square foot. NASA review of the cost estimate has validated that the estimate is within the range of present NASA cost experience escalated to the 1984 construction time frame.

QUESTION NX-10:

Modifications to the 30 x 60 Wind Tunnel Langley, $4.4 million: What are the long range plans for the use of the Tunnel? How do those plans relate to the 40 x 80 Tunnel at ARC and do they both accommodate research in the same velocity and Reynolds Number regimes?

ANSWER NX-10:

The long range plan includes continuing research on the low-speed stability and handling characteristics of civil and military high-performance aircraft concepts. The 30X60-ft. wind tunnel is a key facility in these plans because of its unique capabilities for such investigations on fixed wing aircraft configurations in two different modes of testing. The tunnel is used in a conventional wind-tunnel mode in which large scale models are mounted on a balance system. Its primary use, however, involves the free flight of dynamically scaled models, remotely controlled by engineer test pilots.

The unique free-flight capability provided by this large open-throat tunnel has been used extensively for essential low-speed high angle-of-attack testing of high-performance military aircraft such as the F-16XL and the experimental forward-swept-wing X-29A. It will continue to support such research on advanced configurations in the future.

The long range plan for the 40X80X120-ft. tunnel at Ames is directed at helicopter and VTOL aircraft concepts. Although this facility is a low-speed tunnel compared with transonic and supersonic tunnels, it has the capability of testing at speeds up to 300 mph -- almost three times the 110 mph maximum speed of the 30X60-ft. tunnel. It can, therefore, test advanced high-speed rotorcraft over their entire speed range and is planned largely for this purpose. All testing is done with the vehicles or large-scale models mounted on the tunnel balance system.

While some research could be accommodated in either tunnel in the same velocity and Reynolds number regimes, the higher-speed 40X80 tunnel testing can provide data at nearly three times the30X60 Reynolds number. Alternatively, the testing of larger-scale models in the 80X120-ft. leg can provide data at more than twice the 30X60 Reynolds number at the same velocity. The higher Reynolds number is very important for the research on the

efficiency and performance of advanced rotorcraft. For the low-speed stability research on conventional aircraft in the 30x60-ft. tunnel, the tunnel's unique free-flight capability outweights its Reynolds number disadvantage. Both facilities figure prominently in NASA's long-range aeronautical R & T plans.

QUESTION NX-11:

Small Engine Component Testing Facility Modifications, Lewis Research Center $7.0 million: Is NASA doing any independent engine design and development on their own or does the work support industry? Should NASA continue to support private industry in this area? How does that relate to the Administration's policy?

ANSWER NX-11:

NASA is not designing or developing small turbine engines. NASA is planning to generate an advanced component technology base that would enable U.S. industry to design superior small turbine engines. This type of technology development is fully consistent with the recently restated national policy and represents a primary NASA responsibility. The work is of a long range nature in which industry does not invest since it is difficult for any one manufacturer to capture the benefits.

Current small engines are much less efficient than the large turbine engines which power transport aircraft. Component efficiencies of small engines are 8 to 10% less than large transport engine components. Due to their small size, viscous layers distort a larger portion of the flow in each small engine component. The Research in this facility will provide data to verify analyses and generate a technology base for the small engines used in general aviation/commuter aircraft and rotorcraft to raise their efficiency toward those of the larger turbofan engines.

QUESTION NX-12:

Given the current low rate of inflation what is justification for a 15% increase in Facility Planning and Design? What additional tasks need to be performed over FY 1983?

ANSWER NX-12:

The FY 1984 Facility Planning and Design (FP&D) request of $9.2 million is actually less than a 15% increase over the $8.250 million FP&D requested in FY 1983. To accommodate a $2.5 million appropriations reduction in the FY 1983 CoF minor programs and FP&D, NASA applied $250,000 of the reduction to the FP&D account. Thus, the requested FP&D amount for FY 1984 in part reflects the need to recover from the reduction made in FY 1983.

Although the $9.2 million FP&D request includes a modest factor for inflation commensurate with current cost escalation projections, most of the increase responds to increasing

requirements in the FY 1984 and beyond CoF programs. These funds will be used primarily to support FY 1985 project designs and FY 1986 and FY 1987 preliminary engineering reports.

The request provides NASA the necessary advance planning resources to adequately respond to future facility requirements that, although not fully defined today, are contained in our long range plans. Typical of the larger CoF projects which are anticipated are the facility for new numerical aerodynamics simulation equipment at Ames Research Center and major modifications of the Altitude Wind Tunnel at Lewis Research Center for icing and propulsion research. Other candidates include any ground facilities that may be required for a space station initiative, and additional Shuttle payload processing capability to keep abreast of increasing flight rates.

In summary, this FY 1984 and FP&D request is a vigorously scrubbed summary of our projected needs for continuing, recurring, one-time and special planning and design requirements, as well as accounting for a small increase in costs due to inflation.

Mr. VOLKMER. Thank you very much, General McGarvey.

I now recognize the gentleman from New Mexico for questions.

Mr. LUJAN. Thank you, Mr. Chairman.

We have had a conversation before about these items in the budget, and I come back to my final question from before. Where can we have some cost saving estimates? Are some of these functions that are performed by NASA, functions that can also be performed and are being performed by private aircraft manufacturers?

General MCGARVEY. I believe, Mr. Lujan, that you will find that the vast majority of our request, particularly in the aeronautical facilities, are unique facilities found only in NASA. For example, the small engine test component facility does not exist any place in industry nor any place in Government today. We do make a very concerted effort with the Department of Defense on a formal coordination process so that we do not duplicate each other's capabilities and facilities.

Mr. LUJAN. Does the Department of Defense conduct a rather expensive aeronautics research program?

General MCGARVEY. Sir, they have one comparable center in the Air Force, at Tullahoma, Tenn., at the Arnold Engineering Center, which has wind tunnels but not of the capabilities of the NASA tunnels. We have the widest spectrum and the most unique tunnels.

Mr. LUJAN. I understand that, and I am not talking about that specific facility, because I understand that is unique. I am not being critical, because I think $150 million for a construction budget is not an exorbitant amount. Again I am probing for areas where we might be able to accommodate a much lower overall deficit in the scheme of Government financing, and that is the purpose of my questions. I am not talking of those unique facilities that you might have but those facilities that might be duplicated with private enterprise or with the military. If there is some possibility of combining some of those functions, we want to do so.

General McGARVEY. I think you will find that in our case, in most cases it is the reverse. Both industry, the commercial aircraft industry in particular, the FAA, and to a large degree the DOD rely heavily on the NASA test facilities and the NASA laboratories, particularly in the development of basic technology and development efforts on the part of NASA.

Mr. LUJAN. Are their budgets the places where we might look for some savings, where we might be able to do a little more cuts on them?

General McGARVEY. I could not speak to those with any authority, sir.

Mr. LUJAN. I am serious about the line of questions. How we can reduce expenditures.

General McGARVEY. Yes, sir. I think you and I discussed it earlier. The NASA capital investments in facilities and equipment in those facilities that we own is a figure of about $7.7 billion today, with an estimated replacement value that would exceed $20 billion. Out of that, the physical plant, the buildings and the land that they sit on and the test facilities, is about $3.5 billion. A $150 million investment is a prudent investment on an annual basis to protect that kind of an investment and to keep it responsive and capable. We think that this is really a hard-scrubbed, lean request that we are submitting.

Mr. LUJAN. I do not quarrel with that statement. I mentioned before that I think the $150 million construction budget and the $1.2 billion operational budget was within the realm. It was lower than what I would normally expect it to be, but even in the most lean of budgets we might be able to find some areas where there might be some cost savings. And maybe you have given that all the thought you can and eliminated all the ones that could have possibly been cut and there are none left.

General McGARVEY. To give you an example, we went through a very intensive review and scrubbing process during the 1984 budget cycle. Our initial requests from our field centers totaled some $398.5 million. Through the internal review process and through OMB, we have now reduced that to $150.5 million and we truly feel that it is a very well-justified and lean figure.

Mr. LUJAN. Thank you.

Mr. VOLKMER. The Chair recognizes the gentleman from Florida for 5 minutes.

Mr. NELSON. Thank you, Mr. Chairman.

General McGarvey, yesterday, thanks to General Abrahamson, he arranged for me to fly home and inspect a number of sites at the solid rocket booster refurbishment facility. Then I reported to him this morning.

I think my question to you, in looking at this facilities budget, is since you do not have anything in the fiscal year 1984 budget for the facility for assembling and refurbishing the solid rocket boosters, what are we going to do? We are going to have a requirement for 24 sets a year soon. Why is that not in the 1984 budget?

General McGARVEY. Mr. Nelson, in our earlier planning, we started out planning to do that activity in the low bay of the vehicle assembly building and made some capital investments in order to do that. The most recent assessments by a number of outside

groups who have looked at it objectively and intensively have determined that about 16 flights per year appears to be the production capability within the existing facilities. Those facilities are quite scattered, as you saw when you went through them yesterday.

Earlier we had received an unsolicited proposal for a contractor's investment in an offsite facility to do the refurbishing work in a central location. That was one of the reasons why you did not see anything in the 1984 program. At the time, we put the fiscal year 1984 budget request together, we were still assessing the offsite contractor's proposal. Then as other elements were raised, such as environmental objections and other things came up which forced us to reexamine a number of options. I am sure General Abrahamson explained to you that we were going to reassess all of the options. I believe Mr. Beggs committed to try to complete that decision-making process early in March.

To get back to your specific question, if we were to modify existing facilities or build a new facility as a Government-owned facility, we obviously would be confronted with a reprograming requirement. It could be that this will yet be an option that we will have to face up to.

Mr. NELSON. In trying to meet the 24 sets per year that have to be produced in the future, you have to move out in 1984, one way or the other; do you not?

General MCGARVEY. I believe the requirement is to exceed 16 flights per year by 1985 in order to support the mission model. About July 1985, I believe is the date.

Mr. NELSON. The original schedule for the construction of a facility that could produce efficiently the 24 sets per year was October 1, 1984. So, one way or another, there is going to be money expended in fiscal year 1984, whether it is going to be a refurbishment of a facility at a certain location or if it is going to be the construction of a facility by the contractor. There is going to be money expended. So what you are saying is, you would be coming back with a reprograming request.

General MCGARVEY. That is true.

Mr. NELSON. When would you anticipate that would come?

General MCGARVEY. As soon as a final decision is made.

Mr. NELSON. He said he would make that decision before the end of this month.

General MCGARVEY. The end of this month or the first week in March, I think he said.

Mr. NELSON. Would your reprograming request be coming immediately thereafter?

General MCGARVEY. If it is required, it would. If it were a contractor investment—and I believe you understand we are looking at options for a contractor-built-and-financed onsite facility, as well as an offsite facility. If one of those were selected, then the reprograming requirement would not materialize. But, if the decision is to modify existing facilities or to build a new facility by the Government, then we would be coming forward with a reprograming request.

Mr. NELSON. And that comes under your bailiwick: facilities, whether it is constructing new ones or whether it is modifying or refurbishing existing ones?

General MCGARVEY. Yes, sir.

Mr. NELSON. So, in effect, if that request is going to be forthcoming for expenditures in fiscal year 1984—and I have heard nothing to the contrary. I have heard that we are running out of time and we have to get moving. So we are really looking at a budget that is about $7.1 billion, plus whatever the facilities request is. Are there any other items in the construction budget that have not been included in this 1984 request that you expect to be coming back with for a reprograming?

General MCGARVEY. There is a very distinct possibility of a reprograming for facility modifications that are required for the Centaur for pad A and B in order to provide the cryogenic fueling and defueling capability of the Centaur on the pad. We have money in the budget and have sufficient funds in the R&D budget to cover the Centaur modifications; but, we do not have funds in the construction program to construct the full lines themselves and the cabling for the control system, which normally would be a construction project. We would have to reallocate those funds from the R&D budget to the C of F budget. We are reassessing that at the moment and expect to come to a decision on it very shortly. It could take the form of a reprograming request.

Mr. NELSON. In that case, you would reprogram it from the R&D budget to the "Construction of facilities" budget?

General MCGARVEY. That is correct.

Mr. NELSON. What would you reprogram to the solid rocket booster construction site?

General MCGARVEY. That would also probably have to come out of R&D. What residual funds that we have in the construction programs, we are attempting to apply against the emergency repair of the 40- by 80-foot wind tunnel accident that occurred at the Ames Research Center in December. We have very little flexibility and very few resources that we could apply to a new requirement through reprograming from within the C of F budget. We would undoubtedly be looking at the R&D resource.

Mr. NELSON. Do we really want to take it out of R&D, or do we just want to give you a supplemental appropriation?

General MCGARVEY. That certainly is another possibility as we go through the 1984 budget cycle.

Mr. NELSON. It is like cutting our throat when we cut out our R&D. That is our insurance for the future.

General MCGARVEY. That is right. I said that because that is the one vehicle for reprograming authority that we have which would permit us to do the Centaur modifications. We are hopeful we can find enough funds in the R&D account to handle it. That possibility is being assessed at the moment for the Centaur modification requirement.

Mr. NELSON. Mr. Chairman, I know I am out of time, but for the gentleman from New Mexico's sake and my sake, I would like to submit a question for the record having to do with our handy-dandy little mobile launch platform, of which there is a tower that you and I, Mr. Lujan, are quite interested in.

I think what I want to ask is: How does the cost for the mobile launch platform No. 3 compare to launch platforms 1 and 2? How will it be different, if at all? And what is the contracting plan for it? Is it going to be one contractor or several; and if there are going to be several, who is going to manage those contractors? Rather than take your good time, Mr. Chairman, I would have that submitted for the record.

Mr. LUJAN. Well, I think I have a little time left, and I would yield it to the gentleman from Florida.

Mr. NELSON. Would the Chairman recognize me?

Mr. VOLKMER. General, do you have an answer at this time? If not, you can submit it in writing.

General MCGARVEY. We would prefer to submit it to you for the record. I really do not know the answer to the last part of the question, as to how we are going to handle it, whether it is all one contractor or if we are going to break it into a number of work packages. I would suspect the latter, if it follows usual procedures for a contract of that magnitude.

In response to the earlier part of your question about the previous two MLP's, they were roughly $14 million and $15 million each. The difference with the $27.3 million is inflation as one factor, and two is that we have updated the third MLP to incorporate the changes that we have made as a result of the first five flights, such as the over-pressure problem that we had with the second flight. We also had to do some major modifications to platforms 1 and 2, which were done out of R&D money as an expediency. We would pick those up in the C of F work at this time.

In addition, we have to provide a mobile launcher platform park site with the utilities, such as, the conditioned air, the electricity, and mechanical systems in order to check out and activate the MLP. The two launch pads will be busy. We will not have a time when we can move it to the pad and put it through the 6 months activation process it requires. This added about $2 to $2.5 million to the cost. That is roughly how the $27.3 million is reached.

[The information follows:]

The actual modification costs for MLP-1 were $12,863,255 and for MLP-2 were $13,828,685. These costs have been escalated to the midpoint of the MLP-3 construction schedule yielding an estimate of $22,200,000. Added to this amount was $2,900,000 for modification work that was funded from R&D on MLP's 1 and 2 for necessary changes during construction. In addition, a $2,200,000 MLP park site is included. It is required to perform validation testing of an MLP away from the actual launch pad. The total construction of facilities funding for MLP-3 is $27.3 million. (In addition, there is another $48 million in R&D funding over five years fiscal year 1982-1986) for the necessary equipment and outfitting.)

There will be no significant differences between MLP-3 and MLP's 1 and 2. Basically, all of these platforms will have the same form, fit and function. MLP-3 modifications will be accomplished through four major contract efforts, some of which will incorporate multiple work packages. The four are:

Disassembly and removal of Launch Umbilical Tower and other non-essential equipment;

Facility and system modifications;

Terminal test and validation contract; and

Final validation by Shuttle Processing Contractor.

In addition, NASA has awarded an architect-engineer contract for design, system integration and construction management. Kennedy Space Center has overall management responsibility for design, construction and activation of MLP-3.

Mr. NELSON. I might say, just in passing, Mr. Chairman, that I want to commend NASA. They have really tried to take a lot of that Apollo structural hardware and adapt it to the shuttle. This is one such item that they are trying to use. They have taken that voluminous vehicle assembly building and they have tried to use it. But for some chokepoints, they still continue to use it, and maybe some safety considerations on the manufacture of the solid rocket boosters as well.

Mr. VOLKMER. I have a couple of questions. One, I notice that you have a request in for composite materials laboratory for Langley Research Center. I personally have no objection to such a laboratory, but I also find that we have, within the Department of Energy, materials laboratories being proposed also for California and Tennessee. Did you know of those laboratories for research and materials and materials processing?

General MCGARVEY. No, sir, I am not personally aware of them, but we will be happy to check those out with our aeronautics program office.

Mr. VOLKMER. I would hate to think that we may be duplicating something. We may not, but I think that should be looked into.

General MCGARVEY. We will be happy to look into that.

[The information follows:]

The Department of Energy materials laboratory being proposed for California will conduct research in advanced materials concepts. Surface properties and catalytic behavior have been identified as two of the research areas. The Department of Energy materials laboratory proposed for Tennessee is intended to consolidate their research in high temperature metals and ceramics, predominantly for nuclear applications. Neither of these Department of Energy laboratories will be conducting research on composite materials for aerospace applications, which is to be the area of research for the laboratory at the Langley Research Center.

Mr. VOLKMER. The other question I have is in regard to the proposed project at the Jet Propulsion Laboratory at Pasadena University. It concerns the type of your stands used for developing, testing, repairing, and calibrating up to stable frequency standards. Is that area susceptible to tremors and earthquakes and things like that?

General MCGARVEY. Yes, sir. It is in an earthquake zone.

Mr. VOLKMER. What effect would that have on your stands?

General MCGARVEY. If you had a major earthquake, that certainly would affect it.

Mr. VOLKMER. Would a major earthquake during a time when you are doing research throw off any of your results?

General MCGARVEY. It would have an adverse impact, and it would set us back. I am sure we would have to retest.

Mr. VOLKMER. What if you even had a minor tremor?

General MCGARVEY. I do not know the answer to a minor tremor, but they have been subjected over the years to a number of minor tremors in that area. Just a few years ago there was an earthquake that destroyed the large veterans' hospital in West Los Angeles. It was certainly felt in the Jet Propulsion Laboratory [JPL] area. The existing facilities, which are very temporary and inadequate were affected; however, it did not put them totally out of operation. They were able to recover and continue to do their calibration work. But, JPL is badly in need of an adequate facility

in which to do this work. I visited JPL the last month, and it is a very makeshift operation for a highly specialized activity.

Hydrogen masers are used as the timing device for deep space planetary navigation. We have six of those in the system today, with two located at JPL as the standards or the ones that they calibrate against. Then we have one at each of the deep space network stations—Spain, Australia, and Goldstone—with one backup at Goldstone. We have purchased additional hydrogen masers for backups at the three deep space network stations. They require recalibration about every 9 months. They are very sensitive instruments. They have to bring them back to JPL and recalibrate them. The scientists at the Jet Propulsion Laboratory are the ones who do the research work, do that repair, as well as the calibration, and in developing new systems, such as the one that I mentioned to you, the very long baseline interferometry navigation system that will be utilized for the Galileo probes from the Galileo spacecraft when it makes the probe entries at Jupiter. It is a very critical requirement.

Mr. VOLKMER. I do not deny that. It is just a question of placement at the Jet Propulsion Laboratory and whether that is a satisfactory placement, not necessarily the project itself.

[The information follows:]

Hydrogen masers are sensitive to disturbances in environmental temperature, barometric pressure, humidity, magnetic field, and to a minor extent, vibration. Temperature variations and magnetic field fluctuations are the environmental factors causing the greatest maser stability problems.

The location is appropriate because this facility will directly support the one-line operations of the Deep Space Network, which is managed at JPL. Also the NASA expertise for development, test, repair and calibration of masers is resident at JPL.

A seismic disturbance will not adversely affect a hydrogen maser unless its magnitude is great enough to cause severe building damage. JPL has been testing masers since the mid-1960's, but little or no test data has been lost because of seismic disturbances. Seismic considerations do not preclude locating this laboratory at JPL where it is needed for upgrading in-line operational support for the masers used by JPL in the Deep Space Network.

Mr. LUJAN. Mr. Chairman, I have one brief question about the various laboratories. Is there any cross-checking from one to another when you are going to establish any kind of a laboratory? Do the various laboratories check with each other and see if they have similar facilities? For example, DOE has been doing exactly what you are talking about, similar to NASA's research into materials that will withstand very high temperatures. It would seem that a joint program or at least checking with each other would occur. Is that built into the system?

General MCGARVEY. I think to a degree, but in our aeronautical research laboratories, we are talking about aeronautical structures and spacecraft structures. The types of materials that will withstand reentry heat at tremendously high speeds, as opposed to what the Department of Energy and other people may be interested in, in the way of composite materials. We are talking about lightweight composites for aircraft structures to improve aircraft efficiency and fuel economies in the aircraft itself.

I think the nature of the research efforts and the experimentation is entirely different, granted without very much knowledge, of what DOE is involved in.

Mr. NELSON. Mr. Chairman, I have one quick question.

I would like you to supply this to us for the record, as soon as possible, please. The question is, What would be the reprograming request for the SRB facilities if the choice is the Tico site adjacent to the Kennedy Space Center?

General MCGARVEY. It would be none if it were the Tico site, which is off NASA land. It would be a contractor investment, and there would be no reprograming request.

Mr. NELSON. Very good. That is even better.

The second question is, What would be the reprograming request if the NASA administrator chooses to refurbish the facility at Marshal, in Huntsville, in dollars? What would be the request?

General MCGARVEY. I would have to furnish that for the record. We have some very cursory information, but we have not evaluated it.

Mr. NELSON. I would appreciate having that information, if you have it, before Mr. Beggs makes his decision.

General MCGARVEY. We will see if we can provide it.

[The information follows:]

The requested information will be provided when the study and analysis have been completed.

Mr. VOLKMER. What is the timeframe?

Mr. NELSON. The timeframe is, he is supposed to make his decision by the end of the month.

Mr. VOLKMER. Thank you very much, General McGarvey. We appreciate your testimony.

Our next witness will be Dr. Walter B. Olstad, Associate Administrator for Management.

Dr. Olstad, we also have a copy of your statement. If you wish to summarize, you may do so. Your statement will be made a part of the record. You may read your statement, however you wish to proceed.

[A biographical sketch of Dr. Olstad follows:]

DR. WALTER B. OLSTAD

Dr. Walter B. Olstad was named Associate Administrator for Management in December 1981. He provides managerial direction involving funtional management and administrative matters such as personnel, supply and equipment, facilities and computer support. He also provides mangerial advice and support to program Associate Administrators, the Deputy Administrator and the Administrator. Olstad had been Deputy Associate Administrator for Aeronautics and Space Technology since October 1979.

Dr. Olstad began his NASA career at Langley Research Center, Hampton, Va., in 1954 as an aeronautical engineer, serving first in the Transonic Tunnels Branch and then in the Reentry Physics Branch. He was named Head of the Gas Physics Section in 1966; Head of the Advanced Entry Analysis Branch in 1969; and was appointed Chief of the Space Systems Division in 1975. From November 1979 to July 1981, he served as acting Associate Administrator for Aeronautics and Space Technology.

A native of Greenport, N.Y. Olstad earned his bachelor's degree in mechanical engineering from Brown University, Providence, R.I., in 1954. He earned his master's degree in aerospace engineering from Virginia Polytechnic Institute, Blacksburg, in 1958, and his doctorate in applied mathematics in 1966 from Harvard University, Cambridge, Mass. During the 1978-79 academic year, he served as a Visiting Professor at Old Dominion University, Norfolk, Va.

Dr. Olstad is the author of more than 40 scientific and technical papers and has specialized in the fields of aerothermodynamics, radiation hear transfer, applied mathematics, numerical analysis and the management of research and development

programs. He is an Associate Fellow of the American Institute of Aeronautics and Astronautics, was editor of the AIAA's Progress Series on Thermophysics in 1979 and Associate Editor of the AIAA Journal of Spacecraft and Rockets. In 1981 he received the NASA Distinguished Service Medal and the American Institute of Aeronautics and Astronautics Thermo Physics Award. Olstad is a member of the Virginia Academy of Science and the Elmer A. Sperry Board of Award.

Dr. Olstad and his wife, the former Helen H. Thompson, reside in Alexandria, Va. They have three children.

STATEMENT OF DR. WALTER B. OLSTAD, ASSOCIATE ADMINISTRATOR FOR MANAGEMENT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; ACCOMPANIED BY ANN BRADLEY, DEPUTY ASSOCIATE ADMINISTRATOR FOR MANAGEMENT, NASA

Dr. OLSTAD. Thank you, Mr. Chairman.

I would like to introduce Ann Bradley, who is the Deputy Associate Administrator for Management.

I have two comments. The first is that fiscal year 1983 research and program management request was reduced by $10 million this summer by the Congress, and then requirements for that budget were increased some $46 million because of the pay raise in October and because of our need to contribute to medicare and the health benefits. We are requesting a supplemental appropriation of about $30 million increase to partially cover those increased requirements. We request that you give that very serious consideration. Second, our 1984 request for research and program management is $1,247 million. About three-fourths of that is for salaries and benefits of our some 22,000 civil servants. I would comment that 1984 is the first year in quite a number of years that we are not planning a reduction in our civil service complement. As a research and development agency, we are very excited about the prospect of being able to bring in people with some of the new skills, and capabilities in new technology areas that we need so desperately to maintain NASA in the forefront of high technology.

In addition, there were some comments earlier about our hiring of recent graduates. We are pursuing very aggressively the opportunity presented by a level complement. With that, I will respond to your questions.

[The prepared statement, plus answers to questions asked of Dr. Olstad, follows:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

STATEMENT
OF
WALTER B. OLSTAD
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS, AND
SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS
COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

Messrs. Chairmen and Members of the Subcommittee:

It is my pleasure to present for you today an overview of the National Aeronautics and Space Administration's (NASA) 1984 Research and Program Management (R&PM) Authorization request, and to review other matters related to the management of the NASA institution.

The Research and Program Management Appropriation provides funding to maintain the in-house capability necessary to accomplish NASA's research and development (R&D) programs. Of these funds, about three-fourths are required to pay the approximately 22,000 NASA civil servants. They represent to all sectors, private or public, a significant portion of this Nation's engineering and technology manpower capability, in aeronautical and space research and in the management and development of space systems. The remaining one-fourth of the funds requested provide for the necessary institutional supplies, materials, equipment, utilities, services and travel to support our staff and operate our Centers.

FY 83 Budget Changes

Before addressing NASA's Budget Request for 1984, I want to discuss with you changes from the 1983 Budget presented to you last year. Congressional action last summer reduced our R&PM Budget request by $10.0 million. In addition, the effect of the increases in civil service pay rates and the Government's share of payments to the social security trust fund for medicare and for increased health benefits premiums have increased our requirements in 1983 by $46.2 million. To cover these increases we are requesting supplemental appropriations of $30.2 million. The difference of $16.0 million and the reduction in the original request of $10.0 million, will be offset by economies in all areas. Reductions in areas other than personnel functions will be through the deferral and delay of purchases, and the rephasing of support contractor funding. While these reductions place a burden on NASA in providing adequate institutional support to the research and development programs, the actions planned are designed to mitigate adverse impact as much as possible. Temporary deferrals generally involve higher costs in the long run and any reduction to our supplemental request for 1983 or in our 1984 request will only compound an already difficult management situation in FY 1984 and beyond.

FY 1984 ESTIMATE

The 1984 budget estimate is $1,247,500,000, of this amount $883,785,000 provides for the personnel and related costs of our civil service staff. The balance of the funds requested will provide a minimum level of travel required to support agency missions; anticipated contractor wage-rates at essentially level staffing; the full-year funding of support service contracts; utilities at projected rates; and a constant level of supplies, materials, equipment and other contracts at anticipated price levels.

This supports civil service staffing at the same level as the current year. For the first time in several years NASA has not planned a reduction in civil service strength in the budget year. This stability of staff, so important to an R&D organization, will permit us to hire a larger number of recent graduates in the scientific and engineering disciplines. Since 1970 the average age of our technical workforce has increase from 39 to over 44. The increased hiring capability will allow us to check this trend. It will also enable us to solve minor skill-mix problems that arose in previous years when we were faced with accommodating ceiling reductions. Although we believe that our workforce is one of the strongest and most creative in the world, we need this influx of people with new viewpoints, different skills, and knowledge of the latest technology in many diverse areas to sustain our excellence and maintain and improve this outstanding national asset.

Now, let me briefly summarize the Research and Program Management Appropriation for 1984, by functional category, as follows:

1. Personnel and Related Costs ($883,785,000): The 1984 estimate for Personnel and Related Costs is based on 21,219 permanent civil service positions. This increase of $7,589,000 above the FY 83 Current Estimate results from the combination of the full-year effect of 1983 changes, including increased pay and benefits costs.

2. Travel ($25,700,000): The 1984 estimate reflects the same level of travel as planned in 1983. The amount requested is that required to cover the expected costs for per diem, air fares and other necessary expenses.

3. Operation of Installation ($338,015,000): Operation of Installation provides a broad range of services, supplies and equipment in support of NASA's institutional activities. The 1984 plan reflects an increase of $38,961,000 over the 1983 Current Estimate. This provides the same level of support to the operations of the various NASA centers as in 1983 at anticipated price levels for 1984. The amounts by subcategory are as follows:

   A. Facilities Services ($186,488,000): The estimate, an increase of $21,532,000 over the 1983 current estimate, is driven by anticipated support contractor and utility rate increses, the full-year funding of support service contracts, and supplies, materials, and equipment at anticipated 1984 price levels.

   B. Technical Services ($59,257,000): The $8,302,000 increase in 1984 covers anticipated contractor rate increases and the full-year funding of such contracts, as well as increased costs of supplies, materials and equipment in this subcategory.

C. Management and Operations ($92,270,000): The $9,127,000 increase in this subcategory is needed to provide for the increased costs of supplies, materials and equipment, the anticipated change in support service contract rates, and the full-year funding of such contracts.

Our 1984 Research and Program Management request is lean. It supports a level program with increases only to cover growth in the cost of doing business. It should be recognized that we have based our estimates on the assumption that rate increases will be significantly lower than we have experienced over the past several years. Even though we have based our 1984 utility estimate on lower rate increases, the unit cost for utilities will continue to rise faster than in other areas. NASA is attacking the utility problem in a variety of ways which includes a continuing conservation program which since 1973 has reduced our energy consumption by 38% even though new facilities and increased program activities are coming on-line.

This concludes my statement on the Research and Program Management Budget. I will now highlight several other institutional items which may be of interest to you.

NASA PRODUCTIVITY AND QUALITY ENHANCEMENT

ORGANIZATION

Last year, I apprised you of organizational changes NASA was in the process of implementing which were designed to improve our institutional operations. We have been operating for about a year now under the new organization. After allowing for the normal "wearing in" period, we are seeing the improvements we sought. The lines of authority and responsibility have been shortened and more clearly defined. The benefits we expected are being achieved, and we have been able to focus more attention on program activities.

PRODUCTIVITY INITIATIVES

We at NASA recognize the need to improve our productivity and the quality of our products. To provide direction, the Administrator has formed a Productivity Steering Committee composed of the top management officials of the Agency.

This Committee has established goals aimed at:

(1) Continuing NASA as a leader in the development and application of advanced technology and management practices which contribute to significant increases in both Agency and national productivity.

(2) Identifying areas where NASA practice may have fallen behind the state-of-the-art in productivity and quality and to initiate actions to effect improvement.

(3) Providing additional incentives for NASA contractors to identify and implement productivity improvements in their operations.

We are undertaking Agencywide initiatives in several areas. First, we have underway a project to promote the effective and efficient application of office automation. This includes various capabilities like electronic mail, calendar routines, interactive data base systems and word processing.

Second, we are seeking productivity gains through much greater use of automatic data processing equipment in our everyday management. The overall information requirements are being validated through a review involving top NASA management and a team has been formed to define and acquire a common hardware base upon which to run common applications programs. This is a difficult challenge in the dynamic world of ADP and requires realistic planning and adequate funding in the early stages to generate long-term savings.

Third, in the area of paperwork management, and in conjunction with the Reform '88 program, we are looking to eliminate or reduce where possible, paper generators such as reports, regulations, instructions and the like. As in the other initiatives we will accomplish this by involving key people from the Headquarters and the field.

Finally, we have begun pilot studies on Quality Circles at three centers. Consideration is being given to expanding this program agencywide. The reasons for focusing our attention on productivity are many; to reduce management and administrative overhead costs, to permit our engineers and scientist to devote more of their precious time to carrying out the agency mission, and to provide leadership by example to both the government and the private sector.

Merit Pay

Last year I discussed with you problems caused by the implementation of Merit Pay under the Civil Service Reform Act. The changes necessitated by the Comptroller General's decision just before the 1981 pay-out caused morale problems among our GS-13 to GS-15 managers and supervisors. During the last year, working with OPM and other agencies, we have been able to revise some aspects of the system. The result has been a more effective program with improved employee acceptance. We are continuing to work internally and with the Office of Personnel Management to further improve the program.

Equal Opportunity

NASA continued to make modest progress in the area of equal opportunity during 1982. The actual number of minority employees fell by 39 to 2,433 because of the overall reduction in the work force complement; however, their percent increased from 11.3% to 11.5%. Minorities in professional positions, on the other hand, rose by 19 to 1237. Within these professional positions, minorities increased from 11.6% to 12.2% in administrative positions and from 7.4% to 7.6% in scientific and engineering positions. A similar pattern occurred for women. Overall their number fell by 91 to 4620, but their percentage increased from 21.6 to 21.8. The number of women in professional jobs, on the other hand, rose by 61 to 1,734. Of these, there was an increase from 30.8% to 32.2% in administrative occupations, and 5.5% to 5.8% in scientific and engineering positions. Minorities and women continued to move into positions of greater responsibility, and increased to 151 and 149, respectively, in management and supervisory positions. This represented an increase from 4.4% to 4.7% for minorities and 4.3% to 4.7% for women. At the end of 1982, handicapped employees comprised 1,278 or 5.4% of NASA's work force. There were 161 or .7% with severe or targeted disabilities, and 562 or 2.4% disabled veterans.

NASA continues to insure the progress of its equal opportunity program. At present, steps are underway to require managerial accountability for EO goals and a drive to recruit and hire minorities and women at the upper managerial levels. These and other efforts will continue in FYs 1983 and 1984, and we expect to make gains in our goal of an integrated NASA work force.

Mr. Chairman, this concludes my prepared remarks. I will be happy to answer any questions you or Members of the Subcommittee may have.

Responses to Written Questions from the February 8, 1983, hearing at which Dr. Olstad testified.

QUESTION N-1:

What is the latest with regard to the situation at Ellington Air Force Base in Texas? (Johnson Space Center depends on Ellington for its aircraft operations, including astronaut training; but the Air Force wants to close this base).

ANSWER N-1:

The airfield property, except for the areas occupied by NASA and the Texas Air National Guard, has been offered by GSA to the City of Houston for development of a general aviation airport. Under the conditions of the proposal, NASA and the Air National Guard will be allowed to remain as tenants and continue to utilize the airfield.

In accordance with the policies of the Property Review Board, "property excessed by a Federal Agency should be transferred to another Federal Agency only upon payment of the fair marker value of the property." OMB has approved NASA's request for the transfer of real properties at Ellington contingent upon the appropriation and payment to GSA of the fair market value of these properties. Therefore, $8.4 million has been included in the FY 1984 CofF budget request.

QUESTION N-2:

What are your plans for hiring young professionals this year and next? What are the prospects for getting the number and quality you want?

ANSWER N-2:

NASA plans to hire approximately 370 new college graduates in FY 1983 and about 450 in FY 1984. These numbers could increase as NASA centers have been encouraged to take advantage of the current good hiring climate and convert other hiring opportunities to opportunities for new graduates. The prospects for getting the number and quality we want are excellent as competition from the private sector has greatly decreased under current economic conditions.

QUESTION N-3:

The FY 1983 R&PM Appropriation contains $10 million less than you asked for. In addition, OMB is asking you to "eat" $16.6 million in increased pay costs. How are you absorbing those losses?

ANSWER N-3:

The $26.1 million reduction to the 1983 plan will be accommodated largely through economies in all areas. Reductions in areas other than personnel functions will be through the deferral and delay of purchases, and the rephasing of support contractor funding. While these reductions place a burden on NASA in providing adequate institutional support to the research and development programs, the actions planned are designed to mitigate adverse impact as much as possible.

QUESTION N-4:

How would you characterize your most recent negotiations with your support service contractors and their relations, in turn, with their labor unions?

ANSWER N-4:

NASA relationships with its support service contractors during 1982 can be characterized as extremely cooperative. This has also been true with the contractors relationships with their respective labor unions in that few labor disputes occurred and there was no impact upon NASA programs and schedules.

In addition, renewal of Collective Bargaining Agreements results in moderation in the escalation of wage rates and fringe benefits.

Mr. VOLKMER. The gentleman from New Mexico?

Mr. LUJAN. Not at this point, Mr. Chairman.

Mr. VOLKMER. The gentleman from Florida?

Mr. NELSON. No questions.

Mr. VOLKMER. Basically, how will you absorb the approximately $16 million plus the $10 million? Is that through holding off hiring people and attrition? There is about $26 million there that you are going to have to absorb; right?

Dr. OLSTAD. That is correct. We will not absorb any of that through a reduction in our complement of civil servants. We will absorb that through some savings in utilities, a slight reduction in travel, other savings in operation of installations, and primarily through rephasing of some contracts which normally we would fund for a full year. What we will do is fund those that begin in the middle of the fiscal year only for that portion of the year that falls within 1983, which will allow us to continue operations at the minimum funding level.

Mr. VOLKMER. As you hire younger professionals, which I say is good because you get more young people, that also reduces some of your personnel costs, does it not?

Dr. OLSTAD. It will reduce the average age, which should affect the average grade. We have, however, based on our 1984 funding request on the grades we actually expect to pay.

Mr. VOLKMER. Right now you have an arrangement at Ellington Air Force Base in Texas. You presently have an $8 million payment that goes to the Air Force for training?

Dr. OLSTAD. That is correct. It is a transfer of funds to the GSA for the transfer of that capability to NASA.

Mr. VOLKMER. Do you foresee that continuing on?

Dr. OLSTAD. That is a one-time payment. We will continue to use that capability. We have used it for a number of years with the Air Force.

Mr. VOLKMER. But that is only a one-time payment?

Dr. OLSTAD. That is correct.

Mr. VOLKMER. So that we will not have to worry about that in the budget in the future?

Dr. OLSTAD. That is correct.

Mr. VOLKMER. The gentleman from New Mexico?

Mr. LUJAN. Thank you, Mr. Chairman. We are talking about that $1.2 billion portion of the budget for operations and salaries and supplies and those sorts of things?

Dr. OLSTAD. Yes, sir.

Mr. LUJAN. Tell me a little bit about this productivity steering committee that you have put together. Is that to look at all these things?

Dr. OLSTAD. Yes, sir, I do not want to get into a long speech on productivity improvement, but as you know, one of the problems we have in this country is in the area of productivity. We have fallen behind a number of our strongest competitors in this areas. We feel that our agency, being a high-technology agency, can make some contribution nationally. We feel that we should set a good example within the Government, and we feel that we can greatly improve our own operation by looking hard at that operation and trying to improve productivity.

Our Administrator feels very strongly about this. As a result, we have established a steering committee which he chairs. Our associate administrators and our center directors sit on that committee. We had our first meeting in January. We looked at things that were ongoing already. We are trying very hard to encourage additional activities, and have a number of specific initiatives going.

We are trying to do this without large front-end funding because we recognize that what we really are trying to accomplish is a more efficient use of those funds. We are trying to phase in these activities and achieve savings in the future within the funding available.

Several of those initiatives include office automation or administrative automatic data processing, which is a much greater and a more effective use of the computer in managing NASA. We are introducing quality circles at several of our centers and looking at expanding that throughout the agency.

Mr. LUJAN. Quality circles?

Dr. OLSTAD. Quality circles. It is a technique that has recently caught hold here in the United States and a little earlier in Japan to improve the productivity of people. It really does not cost much to implement, but it is a way of getting the people who are actually doing the job to problem-solve and do their job better. It is enlisting them, in effect, and gaining their very positive support. It has been very successful in a number of companies across the country.

Mr. LUJAN. Do you find, because you have had reductions in numbers, that in itself is of some advantage to your effort? If you have fewer, those who are left will do more and better?

Dr. OLSTAD. It is a stimulus for us to try harder to be productive. However, it tends to be a demotivator. When our workforce gets cut, it is a signal to our people that perhaps the job they are doing is not quite so important, which tends to demotivate them. As a result we try very hard to work things on a positive basis and say, "Yes, your job is very important. You are making a large contribution, and we are trying to get more work out of you. We are not trying to put you on the unemployment rolls." We have to be very careful in any of this productivity effort to insure it is a very posi-

tive approach because you depend on all of the people in the agency to work harder. You are asking them to work harder and you want them to be motivated to do that.

Mr. LUJAN. On a very small scale, I can tell you what happened in my office. We are entitled to a maximum of 19 staff, and I reduced that to 15. I started insisting that everybody leave at 5, instead of staying there until 6:30 or 7 o'clock or 7:30 at night, but if it was not all done they would have to come back on Saturday morning.

It did a couple of things. Instead of taking time to visit during the day, saying, "I'll finish it when the phones stop ringing," and that sort of thing, we managed with fewer people and got a lot more efficient. I do not think that, "If you do not finish by Friday night" had that much effect. It was just that they had so many hours in which to do it and there were so many people there to do it. I suppose that the stick was, "If you do not get yours done, you may not be here for very long." But it seemed to me that a fewer number of people did the job more efficiently. From $15,000 to $21,000, that is quite a jump, but I just wondered if that had the effect in a large organization the way it does in a smaller one.

Dr. OLSTAD. It does, but again experience tells us that the carrot is far more effective than the stick. The stick can produce productivity improvements in the short run but tends to lead to reductions in productivity in the long run.

Mr. LUJAN. The carrot was there in that they would leave at 5 instead of 7:30 or 8; and there was enough money for 18, and we divided it among 15.

Dr. OLSTAD. I agree with that. My point is, the carrot is much more effective in the long run.

Mr. LUJAN. Thank you, Mr. Chairman.

Mr. VOLKMER. I have one last question. Are there any funds in the operational budget for any new aircraft for administration for NASA?

Dr. OLSTAD. There is language in the 1983 Appropriations Act providing authority to purchase with approval for two aircraft. There is money only for one the replacement of the Queen Air at the Marshall Space Flight Center with a King Air, and that we have done.

Mr. VOLKMER. No, I mean in 1984.

Dr. OLSTAD. No, there is no money in the budget for fiscal year 1984.

Mr. VOLKMER. I have no further questions. Thank you very much.

Our final witness is Mr. Hosenball, the general counsel.

The text of your prepared remarks will be made a part of the record.

[A biographical sketch of Mr. Hosenball follows:]

S. NEIL HOSENBALL

S. Neil Hosenball was appointed NASA's General Counsel on June 12, 1975. He is responsible for overseeing all legal concerns of NASA. Prior to assuming this position, he was Deputy General Counsel from October 1967.

Earlier, he had been Assistant General Counsel for procurement matters and had served for four years at the NASA Lewis Research Center as its Chief Counsel.

Prior to joining NASA in 1961, Mr. Hosenball was in a private law practice in Cleveland, Ohio. He is a veteran of World War II.

Mr. Hosenball is a member of the Administrative Conference of the United States and is currently serving as Chairman of the Committee on Claims Adjudication. He also is member of the United States Delegation to the Legal Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space.

He was awarded the NASA Exceptional Service Medal in 1967 and the Distinguished Service Medal in 1973.

Mr. Hosenball received a bachelor's degree in 1948 from the University of Michigan, Ann Arbor, and an LL.B. degree from Harvard Law School, Cambridge, Mass., in 1951. He is a member of the Ohio and Florida Bar Associations and is admitted to practice before the United States Supreme Court.

A native of New York City, Mr. Hosenball and his wife, the former Rosalyn Green, reside in Washington, D.C. They have three children.

STATEMENT OF S. NEIL HOSENBALL, GENERAL COUNSEL, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. HOSENBALL. Thank you, sir. I am pleased to be here again. I am going to shorten a very short statement.

We have given the committee the administration's bill. We will be formally submitting that bill. Mr. Beggs, the Administrator, will be sending it to the Speaker of the House, and it probably will be referred to your committee fairly quickly.

Basically, the fiscal year 1984 Authorization Act is essentially the same as 1983, except for amounts and two sections that I will just briefly mention. Section 7 has been added to implement the administration's commitment that the Nation must be in a position to operate a four orbiter fleet; it provides for the procurement of constructual and component spares.

As for section 8, we have had problems over the years and they seem to be increasing, in the misuse of our Agency name and initials. By that, I mean the National Aeronautics Space Administration and NASA. Other agencies have a statute, which in most cases provides criminal penalties for the misuse of initials. It covers the FBI, HUD, and many other agencies. We have chosen, on the recommendation of the Department of Justice, to go a civil action route, which would permit us to get a temporary restraining order or preliminary injunction to prevent the misuse of the name.

That is all I have, Mr. Chairman. If there are any questions, I would be glad to respond.

[The prepared statement, plus answers to questions asked of Mr. Hosenball, follows:]

February 8, 1983

Testimony of
S. Neil Hosenball
General Counsel

I am pleased to be here once again to testify before you on the NASA FY 1984 Authorization Act. The Act is the same as FY 1983 except for the amounts authorized and the addition of two Sections, Section 7 and 8.

Section 7 has been added to implement the Administration's commitment that the nation must be in a position to operate a four orbiter fleet. The proposed section does this in two ways; it extends production capability and it provides for structural and component spares to assure that Shuttle operations will continue if unforeseen minor problems, modifications, or outages were to occur in the future.

Section 8 amends the National Aeronautics and Space Act by adding a part entitled, "Misuse of Agency Name and Initials." Over the years we have encountered numerous instances of misuse of the NASA logo, the acronym, "NASA," and claims of approval of or development by NASA. We expect these problems to increase as the Space Shuttle becomes operational and more opportunities are made available for its commercial use. It would be particularly unfair, for example, to those who have participated in such activities and through private investment have achieved commercial success, to have to contend with false or misleading statements of those who have not made such investments.

The proposed language would protect NASA's name and initials against false advertising and related misuse in essentially the same manner as the protection afforded the Central Intelligence Agency. Similar protection is also provided to the FBI and a host of other agencies, the difference being that under our language (and that covering the CIA), the protection is obtained by civil proceedings in district courts to enjoin prohibited acts or practices, rather than through criminal proceedings which could also involve fines and imprisonment.

There is, presently, no means of direct enforcement when unauthorized, false or misleading use of NASA's name or initials is found to exist in relation to a business or commercial activity. Corrective action requires investigations founded on unfair trade practices and/or the trademark laws, usually in conjunction with the Federal Trade Commission and/or similar state agencies. These investigations are difficult and time consuming, with the outcome often speculative. The opportunity for direct enforcement would be more prompt and sure with this amendment to the Space Act. This would benefit both the consuming public and the commercial competitors of those engaged in such unauthorized or misleading activities.

There are, of course, a number of authorized or proper activities in connection or in association with NASA under which the NASA name may be used in an accurate, factual manner that does not create a false or misleading impression. There is no intent by this section to change NASA's policies, practices and procedures in this regard. This language will only afford NASA a better means of corrective action where the NASA name is used in a manner reasonably calculated to convey the false or misleading impression of a relationship with NASA which in fact does not exist.

QUESTION G-1:

With the rapid maturing of the Space Shuttle Program, the Administration is being called upon more and more to allow the private sector to commercialize NASA developed hardware.

(a) What legal form, if any, will be required to transfer this technology (Comsat type quasi-government organization)?

(b) What role do you see Congress addressing in this issue?

ANSWER G-1:

(a) The legal form to transfer NASA-developed technology depends heavily on the technology that you are trying to transfer. In the case of Comsat, the private sector used NASA technology as well as its own to manufacture communications satellites which were then sold to Comsat. NASA's role under the Comsat Act was to provide launch services as well as other technical assistance to Comsat. NASA Space Act authority permits NASA to enter into agreements with public and private entities to use NASA services, facilities and equipment on a reimbursable basis. It is this Space Act authority that allowed NASA to provide similar services to other domestic and foreign satellite communications companies and organizations. This same authority could be used to allow private enterprise the use of NASA services, equipment and facilities in support of the launch by the private sector of expendable launch vehicles. The technology of the launch vehicles themselves now largely rests with the manufacturers of the various expendable launch vehicles. The transfer of Shuttle technology is much more complex. The facilities required to launch and operate the Shuttle are located at the development centers such as the Kennedy Space Center, the Johnson Space Center and the Marshall Space Flight Center. In addition, the refurbishment activities required by the Shuttle and the increasing flight rate make operations more complex. If and when a decision is made to transfer the Space Shuttle to the private sector, the Comsat type organization could be one approach. Other alternatives are a government corporation or a regulated private corporation if there is an absence of adequate competition in the provision of launch services.

(b) Congress will certainly want to follow this issue at least for the purposes of insuring international agreements are complied with by the private sector and that foreign policy and national security interests will be adequately protected.

QUESTION G-2:

Regarding protection of the NASA "name"

Have you cleared this provision with Justice and the other cognizant agencies?

ANSWER G-2:

This provision was cleared with Legislative Counsel at the Department of Justice who cleared it with both the civil and criminal divisions.

QUESTION G-3:

How active a role does the General Counsel's Office see itself playing in the whole commercialization activity if any?

ANSWER G-3:

As in the past, the Office of General Counsel will provide legal support and assistance to all elements of NASA involved in policy development or implementation of commercialization activities. To the extent required, the Office of General Counsel will itself participate in contracts or negotiations with commercial entities. The Office will continue to be responsive to requests for information from private companies, especially when information regarding government policies and positions relating to commercialization activities are not otherwise readily available.

Mr. VOLKMER. The gentleman from New Mexico?

Mr. LUJAN. Have you been having trouble with that?

Mr. HOSENBALL. Yes; the problem is, we do not have any independent authority, so we have to go to the FTC or the Postal Inspectors, or a State agency. By the time they get anything done, the harm has been done or they have disappeared, taking people's money with them. This way, as soon as we learn of it, we can go to the Attorney General, go in for a TRO, serve it on them, and stop it. That is the reason we are asking for the legislation. It seems to work very effectively.

Mr. LUJAN. Is this for T-shirts and that kind of thing?

Mr. HOSENBALL. I do not know if just recently you went past Goddard. You would see "NASA carpets." We even had one group which was the "National American Singles Association" advertising as NASA. There are some more serious than that, where our name is used to endorse products which have not been NASA products. We have come across many fraudulent cases, and that is why we are trying to stop such activities. It is our reputation, and we are jealous of it.

If the NASA name is used in a misleading manner, yes, we would go after them. There are many occasions when we authorize people to use "NASA," and we will continue to do that in appropriate cases. It is really the fraudulent misrepresentation we are concerned about.

Mr. VOLKMER. Mr. Hosenball, what legal problems do you foresee in the future in regard to what I call "privatizing" the space effort, whether it is private enterprise, private individuals putting up the ELV's or what? What are you doing in anticipation of that?

Mr. HOSENBALL. We have been studying that problem for a little while now. I think you probably are aware that we have a National Academy of Public Administration study being conducted right now, and we are hopeful we will get the results in the spring. We also have a great deal of in-house effort, including effort within my office, to identify legal problems associated with privatizing ELV's as well as other proposals that have been submitted.

We have a very flexible statute, but there are fiscal restraints cutting across all agencies, including NASA, that we are looking into to see what sort of problems would exist for a private entrepreneur. I can express a personal opinion. I think the Government has to play a limited role for national security reasons. A launch vehicle is an intercontinental ballistic missile, if you will. The Government has to play a role where it affects foreign relations, if in fact the company will be negotiating with foreign governments who run their post, telephone and telegraph for example. You might want some State Department input. And certainly I think range safety activity is a Government function.

We are trying within NASA and the other Government agencies involved, as well an interagency group, to try to come up with a policy. We are hopeful that policy will be forthcoming sometime this year. I cannot predict when. So we have been looking at it. As you are aware, there are many proposals to privatize the ELV's certainly.

Mr. VOLKMER. In the event we see more commercial or private industry getting into the expendable launch vehicles what, if any-

thing, are you doing to protect the image of NASA? So far, NASA has really been the one who does all the launching of satellites, except the military.

Mr. HOSENBALL. I do not see too much of a problem there. It is a true statement if they say it was a NASA-developed launch vehicle. Titan would have been an Air Force-developed launch vehicle. Delta would be, again, a NASA launch vehicle. What we look for is any misleading advertising. We have had that in the past where there has been a NASA product that has been developed and identified as a NASA developed product, but changes have been made and it is no longer the same product, if you will.

If we have the legislation we can stop it. I do not think our major contractors are going to do anything like that. I would suspect the aerospace contractors will be the ones that will get into the private launch business. They are just as careful of their reputation as we are of ours. I feel fairly confident of that.

Mr. VOLKMER. What prohibitions, if any, would there be on an aerospace contractor, or contractors, going ahead and manufacturing, if they had the financing, a launch vehicle and then selling it out to various people?

Mr. HOSENBALL. There is currently a clearance process for private launches.

Mr. VOLKMER. Let me first assume that McDonnell Douglas manufactures the Delta. And let us say a group of people got together and decided they would like to have McDonnell Douglas manufacture a Delta for them and they were going to place some instruments or communications or whatever in orbit. What prohibitions are there right now for that not to happen?

Mr. HOSENBALL. There are several. One is that chances are McDonnell Douglas is using Government tooling somewhere along the way, and they will probably have to get permission to use the tooling to manufacture a private Delta. But, I think even more importantly there is a system now that was used with SSI, Space Services, Inc., that launched off Matagorda Island. They had a launch vehicle, and the process that they had to go through, although it was a suborbital launch, was to get FAA permission, a waiver, if you will, from the Federal Aviation Regulations because they go through controlled airspace. They also had to get authority from the FCC for telemetry and guidance, for frequency allocations. Then, interestingly enough, they had to go to the Department of State, to the Munitions Control Board, because the State Department considered that launch an export of something on the munitions list. In addition, the Bureau of Alcohol, Tobacco and Firearms got into it because they were shipping explosives, solid rocket motors, across the country.

So there are some Government hurdles to go through before you, in fact, can launch a private launch. NASA also obtains frequencies from an IRAC committee, a Government committee, and we do cooperate with the FAA during a launch, as well as the Maritime Commission to give notice to airmen and notice to mariners. So, NASA goes through some of the same procedures as a private launch activity. We do not go through munitions control, but there are coordinations within the Government in order to make sure that things are being done to insure safety and other requirements.

They also had to notify NORAD before the launch because there are some notification provisions that we comply with and the Soviets comply with so that people are aware that it is a test or a scheduled flight for certain purposes. So, there is a whole series of things they go through.

Mr. VOLKMER. I remember the incident, but I did not get into detail. Was the launch vehicle that was used one that had been previously developed under NASA, or do you know?

Mr. HOSENBALL. It actually was based on a Minuteman. Because we think we have a responsibility to allow development of launch vehicles in the private sector, we had a Minuteman motor which we made available to them on a reimbursable basis. They paid us $300,000, and that money went to miscellaneous receipts, because it was an old motor. If we could not apply it somewhere to reimburse us, it would go to miscellaneous receipts.

Mr. LUJAN. Do you get royalties from people making those hats and T-shirts?

Mr. HOSENBALL. No; on occasion we do get royalties from NASA patents that we license but not from people that are selling NASA hats and NASA T-shirts and the rest.

Mr. LUJAN. They cannot get into trouble doing that, can they?

Mr. HOSENBALL. If it is in good taste, we will probably give them permission. We have given permission to do that. We certainly think that down at the Cape, people who visit the Cape do want souvenirs and things like that. So we do not have any problem with that.

Mr. VOLKMER. That will conclude the hearing, and the committee will stand adjourned.

[Whereupon, at 4:40 p.m., the committee recessed, to reconvene at the call of the Chair.]

1984 NASA AUTHORIZATION

THURSDAY, FEBRUARY 10, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The committee met, pursuant to call, at 10 a.m. in room 2325, Rayburn House Office Building, Hon. Harold L. Volkmer (chairman of the subcommittee) presiding.

Present: Representatives Volkmer, Nelson, Mineta, Lowery, Bateman, and Walker.

Also present: Representative Watkins.

Mr. VOLKMER. The meeting will come to order.

Today we will continue our deliberations on the NASA fiscal year 1984 budget request by hearing from three key program offices: the Office of Tracking and Data Systems, the Office of Aeronautics and Space Technology, and the Office of Technology Utilization.

Although not in the limelight of high visibility to the outside world, these offices play a very key role in carrying out the NASA mission in a most successful manner.

This year the Office of Tracking and Data will see the results of more than 10 years of effort with the launching of the Tracking and Data Relay Satellite System [TDRSS]. The concept was conceived in the advanced systems group at NASA and we share your pride in this most advanced communications system and wish you well in the upcoming STS-6 launch.

NASA will continue to grow only if it pays attention not only to the near-term technology requirements but the long-range technology that will be required in the 21st century. This mandate falls on the shoulders of the Office of Aeronautics and Space Technology and the burden at times is great. However, this office must resist the pressure to deal with near term problems only and must keep in high priority those long-range technologies that will keep this Nation the leader in space technology.

The committee takes great pride in the technology utilization program despite attempts by OMB to eliminate the funding for this effort. This program has the potential to reach thousands of our citizens and display in a tangible way the genius of NASA and its people. To say the least, we are disappointed in the funding level in the fiscal year 1984 budget request and hope to examine the priorities closely.

We look forward to the testimony of the witnesses. We will first hear from the Associate Administrator of the Office of Space

Tracking and Data Systems, Mr. Ed Smylie to be followed by Dr. John Kerrebrock of the Office of Aeronautics and Space Technology; Mr. Bob Allnutt, Associate Administration of the Office of External Affairs, accompanied by Mr. Ronald Philips, Director, Technology Utilization and Industry Affairs Division.

Mr. Smylie, you may proceed at this time.

You may proceed by reading the statement or by summarizing it, however you see fit.

Mr. SMYLIE. With your permission I will summarize my statement and submit the complete statement for the record.

Mr. VOLKMER. Fine.

[A biographical sketch of Mr. Smylie follows:]

ROBERT E. SMYLIE

Robert E. Smylie was named Associate Administrator for the Office of Space Tracking and Data Systems at NASA Headquarters, Washington, D.C., in April 1980 after having served briefly in that capacity from July to December 1976. He is responsible for NASA's worldwide tracking and data network that tracks and communicates with all manned spacecraft, unmanned satellites and interplanetary probes. Prior to his present position, he was Deputy Director of NASA's Goddard Spaceflight Center, Greenbelt, Md., from December 1976.

Mr. Smylie came to NASA Headquarters in October 1973 in the Office of Aeronautics and Space Technology. In that office, he held the positions of Deputy Associate Administrator for Technology, from October 1973 to July 1974; and from July 1974 to May 1975, he was the Deputy Associate Administrator for Science. He was the Deputy Associate Administrator for the Office of Aeronautics and Space Technology, from May 1975 to July 1976.

Mr. Smylie was assigned to the Johnson Space Center, Houston, Tx., from 1962 to 1973. He was head of the Environmental Control System Branch in the Life Systems Division, from 1962 to 1964; Chief of the Apollo Support Office, from 1964 to 1966; Assistant Chief for Apollo Support in the Crew Systems Division, from 1967 to 1968; and Chief of the Crew Systems Division, from 1968 to 1973. In these positions, he was responsible for all Division activity in support of the Apollo and Skylab programs including environmental control, thermal control, space suits, portable life support systems, bioinstrumentation, and waste and water management. From 1972 to 1974, he served as U.S. Chairman of the working group concerned with crew transfer and life support systems for the Apollo Soyuz Test Project, the joint U.S., Soviet space mission.

Mr. Smylie received a bachelor's degree cum laude in 1952, and a master's degree in mechanical engineering in 1954, both from Mississippi State University, Starkville. He completed the requirements for a master's degree in management as a Sloan Fellow at the Massachusetts Institute of Technology, Cambridge, in 1967, and has done graduate work at the University of California at Los Angeles.

He has received the NASA Exceptional Service Medal, the Victor Prather Award and various Johnson Space Center Awards. He was the 1974 Chairman of the American Institute of Aeronautics and Astronautics Technical Committee for Life Sciences and Systems. He is a member of Tau Beta Pi, Pi Tau Sigma and Kappa Mu Epsilon.

He and his wife reside in Reston, Va. They have three children.

STATEMENTS OF ROBERT E. SMYLIE, ASSOCIATE ADMINISTRATOR, OFFFICE OF SPACE TRACKING AND DATA SYSTEMS, NASA; NORMAN POZINSKY, DEPUTY; AND RONALD R. DAPICE, DIRECTOR OF ADMINISTRATION AND RESOURCES MANAGEMENT

Mr. SMYLIE. I extend my congratulations to you as chairman of this subcommittee. We look forward to working with you, other member of the subcommittee, and the staff, as we go through the budget deliberations this year. I am pleased to have this opportunity to present the fiscal year 1984 budget request for the NASA space tracking and data systems program.

Seated at the table with me are Mr. Norman Pozinsky, my deputy, and Mr. Ronald R. Dapice, my director of administration and resources management. In my testimony, in addition to discussing my budget requirements, I shall also address acquisition of services via the Tracking and Data Relay Satellite System [TDRSS], review significant accomplishments and activities since last spring, and discuss our current support services to all NASA flight projects. As shown in this first figure (figure 1), we provide tracking, command, telemetry, and data acquisition support to meet the requirements for all NASA programs, which include Earth-orbital science and applications missions, planetary missions, expendable launch vehicles, sounding rockets, balloons, research aircraft, and the space transportation system. The Deep Space Network [DSN] managed by the Jet Propulsion Laboratory, the Spaceflight Tracking and Data Network [STDN] managed by the Goddard Space Flight Center, and various other facilities currently provide this support. A global communications system links the tracking sites, control centers, and data processing facilities.

During the past calendar year, the NASA networks supported data for approximately 55 missions. Tracking and data support was successfully provided to the space shuttle missions during the year. The STDN also received multispectral scanner data from the Landsat-4 satellite launched last July.

Notable was the STDN's ability to react to the change in the STS-3 landing site from Edwards Air Force Base, Calif., to White Sands, N. Mex. In 5 days, a telemetry, voice and command capability was established at White Sands using portable equipment which provided all required support for that landing.

During 1982, the DSN continued tracking and data acquisition support for planetary spacecraft. One of these, Pioneer 10, is almost four light hours from Earth, and is by far the most distant object with which communication has ever been achieved.

We look forward to the next 2 years with enthusiasm and excitement. After many years of planning and preparation, we are about to initiate our new concept in space operations which will greatly enhance our data retrieval capabilities and increase our ability to realize the benefits of space exploration. The first satellite of the Tracking and Data Relay Satellite System [TDRSS] will be launched on the STS-6 early this year, followed approximately 5 months later with the second TDRSS spacecraft. Figure 2 shows the spacecraft mounted to the IUS. The spacecraft is the red area on the bottom up through the top of the gold antenna folded up in the launch configuration. That is the way it appeared at KSC before moving to the pad for launch. We also have a model on exhibit here at the left for your examination. That spacecraft as represented by that model would more than fill this room. So, it is a large, sophisticated, and complicated spacecraft. With this system, the versatility and operational effectiveness of the space shuttle, spacelab, space telescope, the NOAA operational Landsat satellites, and others will be markedly increased over that which would have been provided by ground tracking stations.

With the full operational capability of the TDRSS, planned in fiscal year 1984, many of the existing ground tracking stations used for Earth orbital missions will no longer be required and will be

closed. The remaining facilities will then be consolidated with the DSN stations under management of the Jet Propulsion Laboratory [JPL], or dedicated to support of launch and landing operations. The consolidation will result in a single ground network to support geosynchronous, highly elliptical, and all planetary missions.

In fiscal year 1984, we will look forward to continuing the support of NASA flight projects both for near-earth orbiting satellites, including the space shuttle operational flights, and for deep space probes.

Let me now turn to our budget request. We are requesting a total of $700.2 million for fiscal year 1984, as illustrated in figure 3, to provide support requirements for NASA flight projects. In fiscal year 1984, we will continue to support ongoing missions, along with preparations for the space telescope, Galileo, Gamma Ray Observatory and the Uranus encounter of Voyager 2. Major ongoing efforts are the modification to the DSN which provides for increased aperture for the Voyager encounter with Uranus, and the consolidation of tracking facilities at our stations in California, Spain, and Australia. The request also includes funds for TDRSS service under a modified TDRSS contract for a system dedicated to support space missions.

The increase from fiscal year 1983 to our fiscal year 1984 request is due primarily to three elements. Foremost is the increase required to provide a full year's funding for TDRSS service including the Federal Financing Bank loan payments. Second is a modest provision for inflation in the cost of operating and equipping the various ground support facilities. The third is the consolidation of budget responsibility to the Office of Space Tracking and Data Systems for the program support communications network which handles data, facsimile, and teleconference circuits among headquarters, NASA centers, and contractors. Partially offsetting these increases is a reduction due to the planned phaseout of selected ground stations which I shall discuss later.

In fiscal year 1984, we are requesting $294.7 million for the space network program. The space network is a combination of the TDRSS and the associated NASA ground systems necessary to provide flight support services to low-earth orbital spacecraft. The amount requested will be used to make payments to the Federal Financing Bank to partially liquidate the outstanding debt and to make payments to NASA's contractors for operation of the space network.

TDRSS was originally conceived as a shared system providing both commercial satellite communications and government mission support capabilities. After thorough review of NASA support requirements and their relationship to the operation of a shared system, and after extensive coordination with both the administration and Congress, a contract modification was executed in December to convert the contract to provide dedicated support to space missions. The contractor will remain the owner-operator but has relinquished its rights to use the commercial segment, commonly referred to as "Advanced Westar." NASA will have the dedicated use of all six spacecraft. The operational constellation of satellites, as depicted in figure 4, will now consist of three, rather than four spacecraft. NASA gains improved management flexibility and con-

trol over the operation of the system and has the ability to make modifications to both spacecraft and ground terminal systems to meet the needs of flight missions. This change also provides the potential for extending system life since there will be three replacement spacecraft available on the ground to restore full NASA service in the event of spacecraft failure or degradation whereas previously there were two replacement spacecraft to back up NASA and commercial flight interests.

The flight-2 spacecraft, scheduled for launch this summer, has recently completed its environmental testing and is in preship preparation. The flight-3 spacecraft is currently scheduled to be launched in early 1984. Our activities over the next year will focus on the establishment of an operational space network. We plan to have two operational spacecraft on-station to provide support to the first spacelab mission later this year. When the third TDRSS, functioning as an in-orbit spare, has successfully completed its post-launch test period, the network will be fully operational and the phaseout of ground stations will begin; $231.5 million is requested to meet the ground network support requirements for fiscal year 1984. The ground network consists of the spaceflight tracking and data network, the deep space network, and ground facilities support for aeronautical research, balloon flights, and sounding rockets.

The STDN supports launch and orbit phase missions, including support to the space shuttle. The projected STDN workload in fiscal year 1984, includes approximately 40 such missions. To accomplish this, we currently maintain 11 S-band stations, as shown in figure 5, augmented by three shuttle special purpose stations and two UHF air-to-ground shuttle voice sites. Since last year, we upgraded the Dakar, Senegal, station to handle S-band telemetry, voice and command functions to support the shuttle high inclination orbit launches, and also concluded phaseout actions at Quito, Ecuador.

In fiscal year 1984, the STDN will experience a large cutback in stations and personnel when the TDRSS achieves full operational capability. We plan to cease operations, as shown in figure 6, at Ascension Island, Santiago, Guam, Hawaii, Dakar, and Botswana in April 1984, and terminate the UHF air-to-ground capability at Yarragadee and the Air Force Indian Ocean station at the same time. With the STS–8 landing planned for the west coast, we reached a decision to extend the Buckhorn, Calif., station to support the night landing of this mission. In October 1984, we will transfer the Alaskan station to NOAA. Beginning in 1984, under the networks consolidation program, one antenna at Canberra, Madrid, and Goldstone will be transferred to the DSN. Although our budget request for 1984 shows some reduction in levels for that year, full savings associated with station closings will not be achieved until fiscal year 1985 due to costs associated with personnel terminations and closure activities. The Merritt Island and Bermuda stations of the STDN will be retained to provide launch and landing support and the Greenbelt station will be returned also to support the international ultraviolet explorer mission.

The deep space network supports planetary and interplanetary flight projects. Work has begun on increasing the capability of the

DSN to support Voyager 2's encounter with Uranus in early 1986. The two previously approved new 34-meter antennas are being erected, one in Australia and one in California. We also have on exhibit a model of this new antenna for your examination. A very modern, state-of-the-art antenna.

In addition, in cooperation with the Australian Government, the DSN station at Canberra, Australia, will be arrayed with a large Australian radio telescope located near Parkes to provide the required support for the Voyager encounter. We are also working with the European Space Agency for use of their equipment associated with that telescope. We are also planning to support the ISEE–3 mission when it leaves Earth orbit to rendezvous with the comet Giacobini-Zinner in 1985.

Another important activity of our program is tracking and data acquisition support to the aeronautics research, scientific balloon, and sounding rocket activities associated with the Dryden Flight Research facility of the Ames Research Center and the Wallops flight facility of the Goddard Space Flight Center.

Responsibility for the National Center for Scientific Ballooning [NCSB] formerly the National Scientific Balloon Facility, at Palestine, Tex., was transferred to NASA from NSF in October 1982. Our program has assumed the management and budgeting responsibility for tracking and data activities associated with NCSB; $159.8 million is requested for the communications and data systems program for fiscal year 1984. The basic elements of this program include communications, mission control, and data processing.

The NASA operational communications network interconnects all tracking sites, mission and spacecraft control centers, and data processing facilities, and is provided wholly by the leasing of domestic and international circuits. The fiscal year 1984 request includes funding required to accommodate data transfer for high data rate instruments and sensor requirements for spacelab, the Landsat-4 spacecraft, and other missions.

As mentioned earlier, we are centralizing the program support communications within our fiscal year 1984 budget to meet total Agency needs.

The mission control facilities program provides and operates the systems to command and control NASA's unmanned scientific and applications satellites. In this program are the payload operations control centers and related mission support systems which receive, process, and display spacecraft telemetry data and transmit commands. Currently, five POCC's monitor and control some 17 spacecraft. Related mission support systems include a shuttle payload interface facility between the Johnson Space Center and the Goddard Space Flight Center. A dedicated control center is being implemented to control the operations of the space telescope to be launched in fiscal year 1985.

Processing of bulk science data from various spacecraft is another significant support function provided by our program. In fiscal year 1984, we will continue to process both digital and image data from NASA's scientific and applications space programs. An important addition is a facility to process data from spacelab and

other missions. This activity is on schedule to meet the first spacelab launch.

We are requesting $14.2 million for our advanced systems program to accomplish studies and technological developments needed to aid our planning and to assure more efficient and cost-effective mission support in the future.

In summary, the space tracking and data systems program is continuing to provide mission support for all flight program requirements.

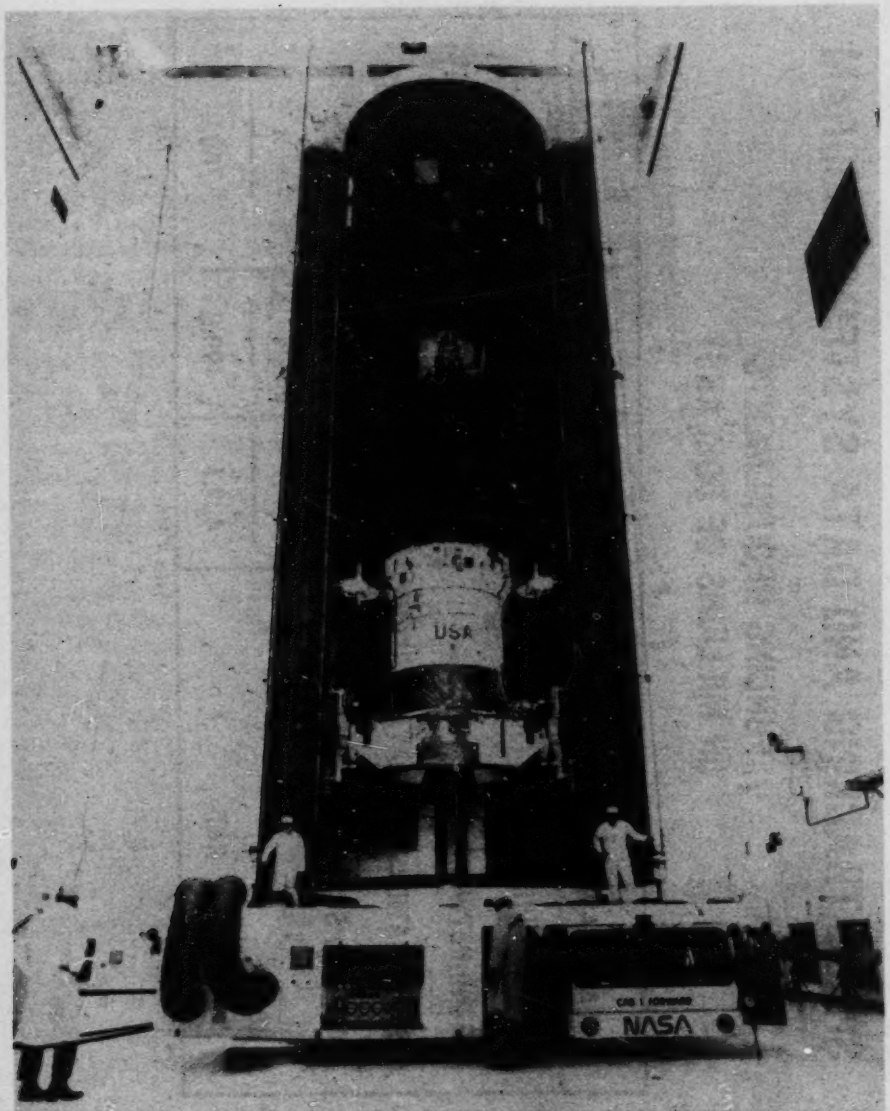
In fiscal year 1984, we look forward to the challenge of supporting the ongoing tracking, command, and data requirements for earth-orbital and deep space missions as we move toward full operational capability of the TDRSS and the consolidated ground networks.

The requested funding level of $700.2 million for our space tracking and data systems program budget provides the minimum resources necessary to meet our support requirements.

Mr. Chairman and members of the subcommittee, this concludes my statement. I appreciate this opportunity to meet with you to discuss NASA's space tracking and data systems program. I urge the full support of the subcommittee of our fiscal year 1984 budget request.

I am prepared to answer questions at this time. Thank you.

[Figures 1-6 of Mr. Smylie's oral presentation, plus his prepared statement and answers to questions, follow:]



TDRS-A ASSEMBLED WITH IUS

FIGURE 2

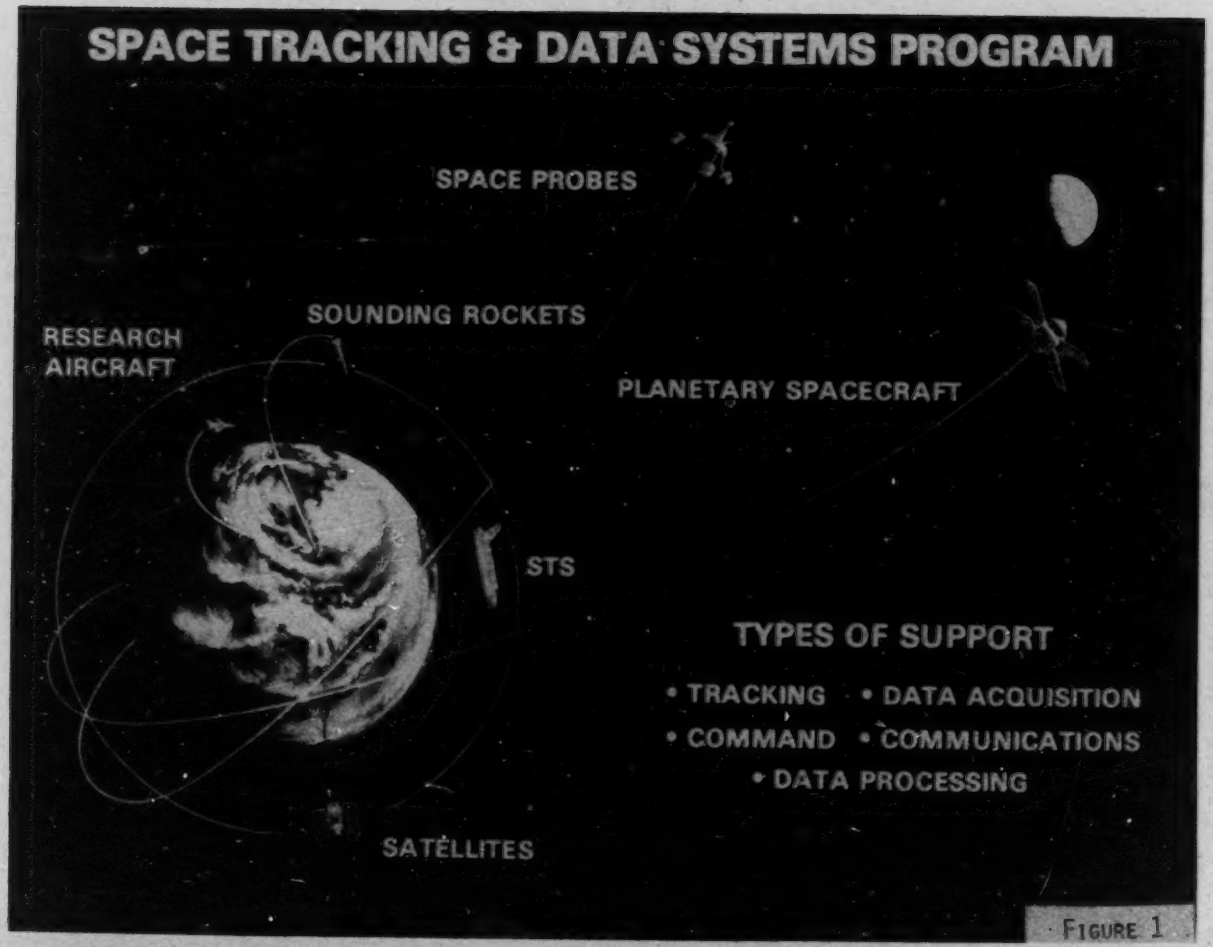

SPACE TRACKING & DATA SYSTEMS PROGRAM
SPACE PROBES
SOUNDING ROCKETS
RESEARCH AIRCRAFT
PLANETARY SPACECRAFT
STS
SATELLITES
TYPES OF SUPPORT
• TRACKING • DATA ACQUISITION
• COMMAND • COMMUNICATIONS
• DATA PROCESSING

FIGURE 1

SPACE TRACKING AND DATA SYSTEMS PROGRAM

FUNDING REQUIREMENTS
(IN MILLIONS OF DOLLARS)

RESEARCH AND DEVELOPMENT	FY 1982	FY 1983	FY 1984 BUDGET REQUEST
SPACE NETWORK	21.8	103.8	294.7
GROUND NETWORK	237.5	242.4	231.5
COMMUNICATIONS AND DATA SYSTEMS	130.3	139.3	159.8
ADVANCED SYSTEMS	12.5	13.4	14.2
TOTAL R&D	402.1	498.9	700.2

FIGURE 3

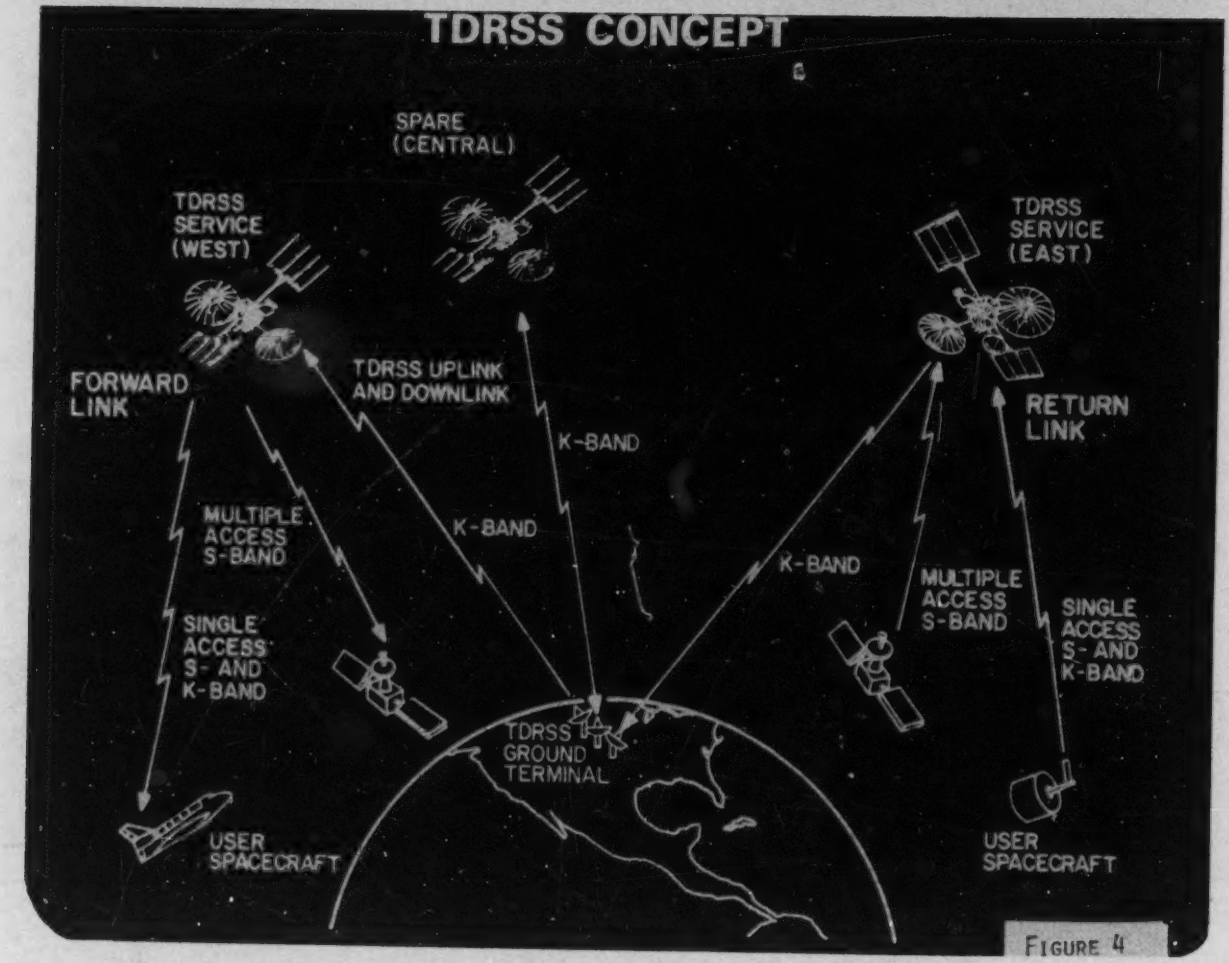

TDRSS CONCEPT
SPARE
(CENTRAL)
TDRSS
SERVICE
(WEST)
TDRSS
SERVICE
(EAST)
FORWARD
LINK
TDRSS UPLINK
AND DOWNLINK
K-BAND
RETURN
LINK
MULTIPLE
ACCESS
S-BAND
K-BAND
K-BAND
MULTIPLE
ACCESS
S-BAND
SINGLE
ACCESS
S- AND
K-BAND
SINGLE
ACCESS
S- AND
K-BAND
TDRSS
GROUND
TERMINAL
USER
SPACECRAFT
USER
SPACECRAFT

FIGURE 4

FIGURE 5

GSTDN BASELINE STATION OPERATIONS TERMINATION PLAN

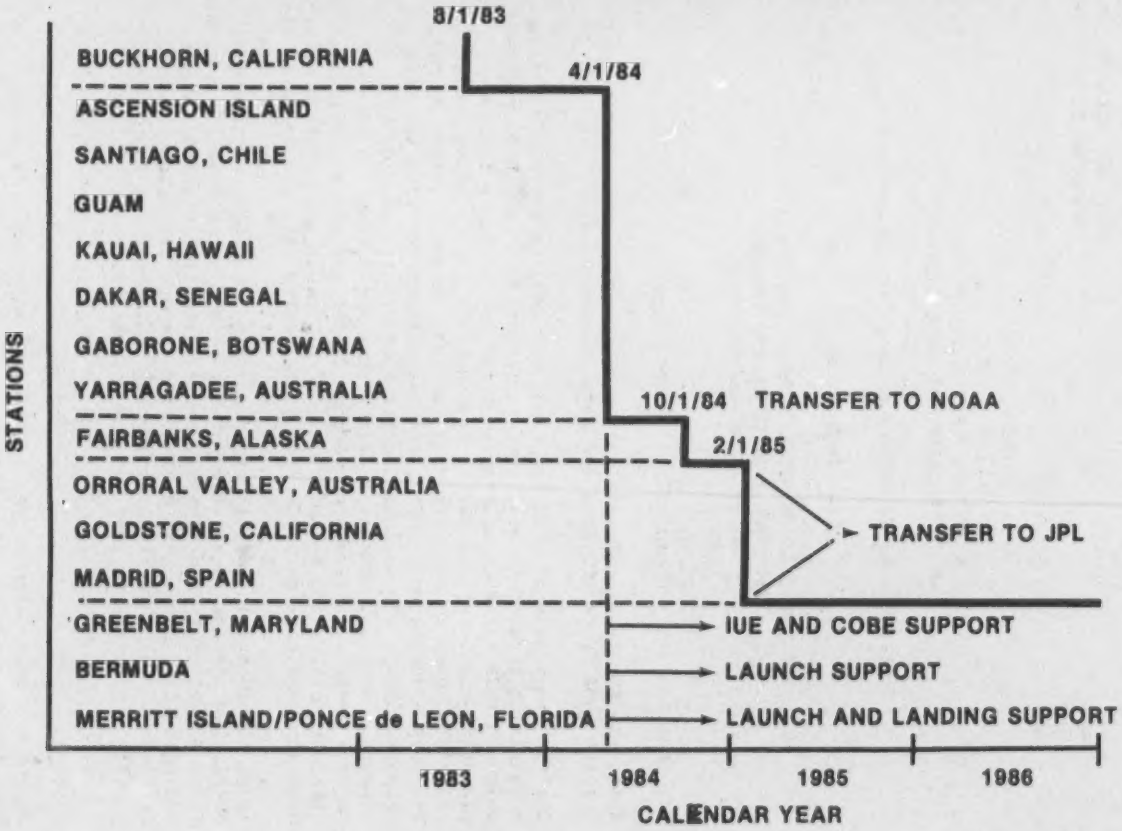


FIGURE 6

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS

STATEMENT OF
R. E. SMYLIE
ASSOCIATE ADMINISTRATOR FOR
SPACE TRACKING AND DATA SYSTEMS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

Mr. Chairman and Members of the Subcommittee:

Thank you for this opportunity to present the FY 1984 budget request for the NASA Space Tracking and Data Systems Program.

Our program provides vital tracking, command, telemetry, and data acquisition support to meet the requirements for all NASA programs which include Earth-orbital science and applications missions, planetary missions, expendable launch vehicles, sounding rockets, balloons, research aircraft, and the space transportation system. The Deep Space Network (DSN), the Spaceflight Tracking and Data Network (STDN), and various facilities currently provide this support. A global communications system links tracking sites, control centers, and data processing facilities which provide real-time data processing for mission control, orbit and attitude determination, and routine processing of telemetry data for space missions.

In my testimony, in addition to discussing my budget requirements, I shall also address acquisition of services via the Tracking and Data Relay Satellite System (TDRSS), review significant accomplishments and activities since last Spring, and discuss our current support services to all NASA flight projects. But, first, I would like to quickly highlight progress and some of our planned activities.

HIGHLIGHTS

During the past calendar year, 1982, the NASA networks acquired data for approximately 55 missions. Outstanding tracking and data support was provided to the Space Shuttle missions during the year. To support the STS-3 landing at the Northrup Strip, a temporary tracking station was established at White Sands, New Mexico, and for the STS-4 mission, an S-Band telemetry, voice and command station was added to the Dakar, Senegal, facility. The first Tracking and Data Relay Satellite spacecraft was completed and checked out, and was delivered to the launch site. Thus, after many years of planning and preparation, we are about to initiate our new concept in space operations which will greatly enhance our data retrieval capabilities and increase our ability to realize the benefits of space exploration. The first satellite of the Tracking and Data

Relay Satellite System (TDRSS) will be launched into orbit early this year, followed approximately five months later with the second TDRS spacecraft. With TDRSS, the versatility and operational effectiveness of the Space Shuttle, Spacelab, Space Telescope, the NOAA Operational Landsat Satellites, and others will be markedly increased over that which would have been provided by ground tracking stations.

In FY 1984, we will look forward to continuing the support of NASA flight projects, both for near-Earth orbiting satellites, including the Space Shuttle operational flights, and for deep space probes. Numerous applications and scientific Earth orbiting missions will be supported including the Nimbus, Landsat-4, International Ultraviolet Explorer, International Sun Earth Explorer, Applications Technology Satellites, Solar Maximum Mission, Infrared Astronomical Satellite, Dynamics Explorer, and the Solar Mesospheric Explorer. Planetary missions support will continue for Pioneers 10 and 11, Pioneer Venus, and Voyagers 1 and 2, as well as limited support for Helios and earlier Pioneer missions.

With the full operational capability of the TDRSS, planned in FY 1984, many of the existing ground tracking stations will no longer be required and will be closed. Ground stations planned to be closed during the Fiscal Year are Guam, Hawaii, Ascension, Santiago, Dakar, and Botswana, along with termination of Shuttle voice communications at Yarragadee, Australia, and the Air Force Indian Ocean Site. The remaining facilities will then be consolidated with the DSN stations under management of the Jet Propulsion Laboratory (JPL), or dedicated to support of launch and landing operations. The consolidation will result in a single ground network to support geosynchronous, highly elliptical, and all planetary missions.

Having touched on some of the highlights of our program and the challenges ahead, let me now turn to our budget request.

FY 1984 BUDGET REQUEST

We are requesting a total of $700.2 million for FY 1984 to provide for continuation of our vital tracking, command, telemetry, data acquisition and data processing to meet all our support requirements for NASA flight projects. In FY 1984, support will continue for ongoing missions, along with preparations for Space Telescope, Galileo, Gamma Ray Observatory (GRO) and the Uranus Encounter of Voyager 2. Major ongoing efforts are the modification to the Deep Space Network (DSN) which provides for the increased aperture to the Voyager encounter with Uranus and the consolidation of the Spaceflight Tracking and Data Network (STDN) stations in California, Spain, and Australia with the DSN stations at these locations.

The FY 1984 budget request also includes funds for providing TDRSS service under a modified TDRSS contract to provide for a system dedicated to providing support to space missions. Provision has also been made in the request to initiate an orderly phaseout of several ground STDN stations in 1984 when the TDRSS is operational.

The increase from FY 1983 to our FY 1984 request is due primarily to three elements. Foremost among these elements is the increase required to provide a full year's funding for TDRSS service including

the Federal Financing Bank (FFB) loan payments. Another element accounting for the increase is the provision for inflation to operate and equip the various ground support facilities. The third element is the consolidation of budget responsibility to the Office of Space Tracking and Data Systems for the Program Support Communications (PSC) Network which handles data, facsimile, and teleconference circuits among Headquarters, NASA Centers, and contractors. Partially offsetting these increases is a reduction due to the planned phase-out of selected ground STDN stations when TDRSS is operational and a decrease in the funding level for the Deep Space Implementation Program associated with the network reconfiguration.

The budget has been restructured to more appropriately present our program requirements for the new era of the Space Transportation System and the Tracking and Data Relay Satellite System during the upcoming years. The restructured budget also achieves consistency with program management responsibilities within the Office of Space Tracking and Data Systems. The restructuring consists essentially of a regrouping of the previous budget line items intc the Space Network, Ground Network, Communications and Data Systems, and Advanced Systems. The subsequent portion of my statement addresses these areas.

SPACE NETWORK

In Fiscal Year 1984, we are requesting $294.7 million for the Space Network Program. The Space Network is the title we have applied to the combination of the Tracking and Data Relay Satellite System (TDRSS) and the associated NASA ground systems necessary to provide our flight support services to low-Earth orbital missions compatible with TDRS. The elements of this network include the Tracking and Data Relay Satellites (TDRS) and the White Sands ground terminal, the NASA Ground Terminal the Network Control Center (NCC), the Operations Support Computing Facility, the Bilateration Ranging Transponder System, the Simulations Operations Center and the Compatibility Test Vans.

The satellites and ground terminal of the TDRSS provide for communication between user spacecraft (i.e., Shuttle, Landsat, etc.) and their ground control facilities. The NASA Ground Terminal (NGT) monitors TDRSS performance, provides fault isolation monitoring for the network and transmits user data into and out of the White Sands area. The Network Control Center (NCC) schedules TDRSS services for all user spacecraft and serves as the Space Network interface with all user ground facilities. The Operations Support Computing Facility provides orbit determination, trajectory analysis, and time correlated position location for flight missions whether supported via the Space Network or the current Spaceflight Tracking and Data Network (STDN). The Bilateration Ranging Transponder System provides precision position location for the Tracking and Data Relay Satellite (TDRS). The Simulation Operations Center and the Compatibility Test Vans provide necessary pre-launch testing, simulations, and interface verification for both user spacecraft and the various network elements to assure the operational readiness of the network to support a given mission. Together, these elements constitute the Space Network.

Let me briefly review our accomplishments since last spring. We have completed the TDRSS test program and shipped the first TDRS spacecraft to the Kennedy Space Center, Florida, for launch. The NCC has been established to provide necessary support to early users. The White Sands ground terminal has been configured to support this first launch. The initial series of network testing has been completed, and we are conducting final simulations and reviews preparatory to launch.

A major change has been made to the TDRSS service contract. TDRSS was originally conceived as a shared system providing both commercial satellite communications and government mission support capabilities. After thorough review of NASA support requirements and their relationship to the operation of a shared system, a contract modification was executed in December to convert the contract to provide dedicated support to space missions. The contractor will remain as the owner-operator but has relinquished its rights to use the commercial segment (commonly referred to as "Advanced Westar"). NASA will have the dedicated use of all six spacecraft provided through the service contract. The operational constellation of satellites will now consist of three, rather than four spacecraft. Spacecraft formerly dedicated to commercial communications service will no longer be required. NASA gains improved management flexibility and control over the operation of the system and has the ability to make modifications to both spacecraft and ground terminal systems to meet the needs of flight missions. This change also provides the potential for extending system life since there will be three, rather than two, replacement spacecraft available on the ground to restore full NASA service in the event of spacecraft failure or degradation.

The second TDRS spacecraft has recently completed its environmental testing and is undergoing the post-environmental comprehensive system test. This will be followed by a series of alignment checks, leak testing, reinstallation of appendages, and final packing and shipment activities for launch this summer. The third TDRS spacecraft is currently scheduled to be launched in early 1984.

Our activities over the next year will focus on the establishment of an operational Space Network. As each TDRS is successfully launched and deployed, it will undergo a series of in-orbit tests to insure that the spacecraft, ground terminal, and other network elements are performing properly. Each spacecraft will then be maneuvered to its appropriate orbital location. Post-launch testing will include tests with Landsat and Shuttle to qualify and demonstrate total data flow compatibility. We plan to have two operational spacecraft on-station to provide support to the first Spacelab mission. When the third TDRS, functioning as an in-orbit spare, has successfully completed its post-launch test period, the network will be fully operational and the phaseout of ground stations will begin.

As mentioned earlier, we look forward to FY 1984 with excitement as we are about to initiate this new concept in space operations.

GROUND NETWORK

To meet the Ground Network support requirements for FY 1984, we are requesting a total of $231.5 million. The Ground Network consists of the Spaceflight Tracking and Data Network (STDN), the Deep Space Network (DSN), and ground facilities support for Aeronautical Research, Balloon Flights, and Sounding Rockets.

SPACEFLIGHT TRACKING AND DATA NETWORK (STDN)

The Spaceflight Tracking and Data Network supports launch and orbital missions, including the Space Shuttle. The projected STDN workload in FY 1984 includes approximately 40 launch support and orbital applications and scientific missions. To accomplish this, we have maintained 11 S-Band stations, augmented by three Shuttle special purpose stations and two UHF air-to-ground Shuttle voice sites. Since last year, we upgraded the Dakar, Senegal, station to handle S-Band telemetry, voice and command functions. We also concluded phaseout actions at Quito, Ecuador.

Since my testimony last spring, the STDN has successfully supported the Space Shuttle missions and has received Multispectral Scanner (MSS) data from the Landsat 4 satellite launched last July. Notable was the STDN's ability to react to the change in the STS-3 landing site to White Sands, New Mexico. In five days, a telemetry, voice and command capability was established using portable equipment which provided all required support.

In the current fiscal year, due to shift reductions in the network, we have reduced manning requirements. In FY 1984, the STDN will experience a large cut back in stations and personnel when the TDRSS achieves full operational capability. We plan to cease operations at Ascension Island, Santiago, Guam, Hawaii, Dakar, and Botswana in April 1984, and terminate the UHF air-to-ground capability at Yarragadee and the Air Force Indian Ocean station at the same time. With the STS-8 landing planned for the West Coast, we decided to extend the Buckhorn, California, station to support the night landing of this mission. In October 1984, we will transfer the Alaskan station to NOAA. Beginning in 1984, under the Networks Consolidation Program, one antenna at Canberra, Madrid, and Goldstone will be transferred to the DSN. We are currently negotiating disposition of the stations to be closed with various other Government agencies. Although our budget request for 1984 shows some reduction in levels for that year, full savings associated with station closings will not be achieved until FY 1985 due to costs associated with personnel terminations and closure activities. The Merritt Island and Bermuda stations of the STDN will be retained to provide launch and landing support and the Greenbelt station to support the International Ultraviolet Explorer Mission (IUE).

DEEP SPACE NETWORK (DSN)

The Deep Space Network supports planetary and interplanetary flight projects. During 1982, the DSN continued tracking and data acquisition support for 11 Deep Space spacecraft. One of these, Pioneer 10, is almost four "light hours" from Earth, and is by far the most distant object with which communication has ever been achieved. In preparing for the critical navigation requirements of Galileo, the DSN measured angles in space as small as 3-millionth's of a degree--

equivalent to determining the thickness of a dime at 20 miles. This technique permitted our Australian station to locate the most distant object yet discovered--a quasar 12-billion light years away. Work has begun on increasing the capability of the DSN to support Voyager 2's encounter with Uranus in early 1986. The two previously approved new 34-meter antennas are being erected, one in Australia and one in California. In addition, the DSN station in Australia will be arrayed with a large Australian radio telescope to provide the required support for the Voyager encounter in cooperation with the Australian government. We are also working with the European Space Agency for use of their equipment associated with that telescope. We are also planning to support the ISEE-3 mission when it leaves Earth orbit to rendezvous with the Comet Giacobini-Zinner in 1985.

The DSN workload in FY 1984 will include support to the Voyagers, the Pioneers, and Helios, as well as preparation for support of Galileo, the International Solar Polar Mission (ISPM), and the Active Magnetospheric Particle Tracer Explorer (AMPTE). Halley's Comet rendezvous missions will also be supported for the international community.

In 1985, STDN facilities at Canberra, Madrid, and Goldstone will be consolidated with the DSN stations under the management of the Jet Propulsion Laboratory (JPL). In addition to supporting planetary missions, this consolidated network will provide support to geosynchronous and highly elliptical spacecraft, emergency support, and support to older spacecraft which are incompatible with the TDRSS, but are still transmitting valuable data. Funding in the FY 1984 request provides for continuing the reconfiguration of the ground network facilities into a consolidated and modern network.

AERONAUTICS RESEARCH, SCIENTIFIC BALLOONS, AND SOUNDING ROCKETS

Another important activity of our program is the tracking and data acquisition support to the Aeronautics Research, Scientific Balloon, and Sounding Rocket activities, accomplished through the Dryden Flight Research Facility (DFRF) of the Ames Research Center and the Wallops Flight Facility (WFF) of the Goddard Space Flight Center (GSFC). Over the years, these facilities have developed into a comprehensive suborbital flight support capability encompassing the complete spectrum of fixed and mobile ground support functions including telemetry, communications, optics, command, space positioning and data processing. For sounding rocket missions, we also perform vehicle and payload impact prediction and range surveillance functions in support of range safety. We have continued the planned upgrade of facilities at DFRF and WFF. In September 1982, a new telemetry acquisition and processing system at DFRF was brought on line which accommodated a 10% increase in workload at the facility in CY 1982. Early in the year, the tracking capability at Wallops was significantly enhanced with the delivery of the last of three mobile C-Band radars. Responsibility for the National Center for Scientific Ballooning (NCSB) (formerly the National Scientific Balloon Facility) at Palestine, Texas, was transferred to NASA in October 1982. Our program has assumed the management and budgeting responsibility for tracking and data activities associated with NCSB.

Our FY 1984 request includes funds to continue the upgrade of support facilities associated with the aeronautics, balloons, and

sounding rocket activities. With anticipated growth in flight research activities at DFRF, we are planning to establish a second telemetry link and a post mission processing system to complete the capability for support of two simultaneous missions. In 1984, at the WFF, we will continue to rehabilitate or replace tracking and data acquisition equipment which is obsolete or too costly to maintain.

COMMUNICATIONS AND DATA SYSTEMS

A total of $159.8 million is requested for the Communications and Data Systems Program for FY 1984. The basic elements of this program include communications, mission control, and data processing.

COMMUNICATIONS

The NASCOM Network is a generic term referring collectively to the global system of circuits, switching, and terminal facilities to provide operational communications support for all NASA projects. NASCOM interconnects NASA's foreign and domestic tracking and telemetry acquisition sites, the launch areas, and the mission and network control centers.

Our Communications support of the Space Shuttle missions has been highly successful. We have completed installation, testing, and verification of the 50 MBS wideband data handling circuit from the White Sands TDRSS ground terminal and are ready to support the high data rate instrument and sensor requirements for Spacelab and the Landsat-4 spacecraft. The baseline system from the TDRSS terminal will provide 4.0 MBS in order to accommodate the combined needs of the Space Transportation System, Spacelab, and Landsat-4 control data requirements. This baseline system will be converted to a broadcast mode of operation.

Testing of a time-division, multiple-access mode of operation using existing domestic satellite transponders will continue in FY 1984. This mode will provide a greater transfer of data using the same transponder capacity. Use of fiber optic and broadband cable systems will be augmented in FY 1984 for relaying computer-to-computer data and to set up cost effective local area networks. A new dedicated NASA microwave system will be constructed and tested in FY 1984 in Australia to support antenna arraying for Voyager support.

As mentioned earlier, in FY 1984, we have centralized within the budget the Program Support Communications (PSC). We have also consolidated the PSC five year requirements and will implement an efficient common user Agency-wide network. In the network acquisition, we will take advantage of the opportunity to competitively acquire the services with the objective of greater effectiveness and efficiency in the use of the network facilities.

MISSION CONTROL

The Mission Facilities Implementation Program provides the systems capability to command and control NASA's unmanned scientific and applications satellite program through Payload Operations Control Centers (POCC's) and related Mission Support Systems (MSS) which receive, process, and display spacecraft telemetry data and transmit

commands. Currently, five POCC's monitor and control some 17 spacecraft. Related Mission Support Systems include a Shuttle Payload interface facility between the Johnson Space Center and the Goddard Space Flight Center.

Funds are required in FY 1984 to operate these POCC's and supporting facilities for the control of on-orbit missions. A dedicated control center is being implemented to control the operations of the Space Telescope to be launched in FY 1985. The Preliminary Operations Requirements and Test System, Payload Applications Software System, plus a test and validation effort are underway to meet the Space Telescope launch date. The control center hardware installation will be completed and pre-launch integration testing with the spacecraft will begin.

Also included in the FY 1984 request are funds for modifications to the existing Multisatellite Operations Control Center (MSOCC) for control of the upcoming Gamma Ray Observatory (GRO) and Cosmic Background Explorer (COBE) spacecraft.

DATA PROCESSING

Processing of bulk science data from various spacecraft is another significant support function provided by our program. Traditionally, the receipt, capture, accounting, and product generation activities have been classified broadly into two major categories; Image and Telemetry (non-image) data processing. The Image Processing Facility (IPF) converts the data from measurements made by the spacecraft of Earth features or phenomena into pictures or their digital representation on computer tapes. In Telemetry data processing, the science data is separated for the individual investigators and recorded on experimenter tapes. Also plots or histograms may be produced. A major subset of the telemetry data processing activities in the future will be the processing of data from Spacelab missions by the Spacelab Data Processing Facility (SLDPF) currently under development.

As indicated previously, the IPF was designed to process data from Earth sensing application missions and currently processes data from Landsat 2 and 3, and the Nimbus spacecraft. The facility continues to meet or exceed production levels required by the users. FY 1984 funds are requested to continue processing Nimbus data.

Telemetry (non-image) data processing support is provided to NASA's free flying science and applications missions and to the upcoming Spacelab flights through a shared facility. For the free flyers, the Telemetry On-Line Processing System (TELOPS) serves as the input processor for telemetry data. A new input processor has been developed for Spacelab flights because these missions generate very complex data streams consisting of analog, audio, instrumentation, and variable rate digital data. The associated output processor, the Univac 1100/82 computer, is shared by these input processors. In FY 1984, these computers will be augmented to improve the reliability and efficiency in their dual role.

In addition to operations and acquisition of data as discussed above, data processing also includes related support computing activities utilizing the large computer complex at the Goddard

Space Flight Center. Until replacement systems become operational, near-real-time support to spacecraft operations such as orbit determination, attitude determination, maneuver computation and command management, and such vital functions as scheduling and modeling are provided by this large computer complex which is about 17 years old. Its operational capability is affected as failure rates increase with age which require larger maintenance expenditures to ensure mission success. Sequential replacement of several computer systems continues. The new Metric Data Facility (MDF) became operational in July 1982 and supported the STS-5 mission successfully. The equipment for the Flight Dynamics Replacement System has been delivered with initial operational capability planned for June 1983. The Command Management System is under procurement with deliveries of equipment anticipated in late 1983. Current plans provide for final delivery of the Orbit Computation System in early FY 1985.

ADVANCED SYSTEMS

For this relatively small but critically essential portion of the Space Tracking and Data Systems Program, we are requesting $14.2 million. The Advanced Systems Program will accomplish the studies and technological developments needed to aid our planning and to assure more efficient and cost effective mission support in the future. Many rapid improvements taking place in the state of the art in telecommunications and computer technology must be examined for their suitability for program applications on a continuing basis. For example, micro-computing technology is being applied beneficially in many of our tracking, telemetry, communications, and computing support systems. Studies and developments are underway to investigate the use of our existing 64-meter antennas at millimeter wave frequencies and to develop an antenna feed system capable of being used at S, X, and K-Band frequencies. Such technology developments will, for example, allow reductions in future spacecraft weight and power, and increase the amount of imaging data that can be returned from distant planetary spacecraft. These improvements will also permit new ground based science experiments to be conducted such as those involving relativity and the search for gravity waves.

These and other technologies being investigated continue to provide a critical base for NASA tracking and data systems future support capabilities.

CONCLUSION

The Space Tracking and Data Systems Program is continuing to provide mission support for all flight program requirements in a cost effective manner.

In FY 1984, we look forward to the challenge of supporting the ongoing tracking, command, and data requirements for Earth-orbital and deep space missions as we move toward full operational capability of the TDRSS and the networks consolidation program. The launch of the first TDRSS spacecraft is scheduled for early 1983, with preparations underway for the second TDRS spacecraft to be launched in mid 1983.

The requested funding level of $700.2 million for our Space Tracking and Data Systems Program budget provides the minimum resources necessary to meet our support requirements.

Mr. Chairman and Members of the Subcommittee, this concludes my statement. I appreciate this opportunity to meet with you to discuss NASA's Space Tracking and Data Systems Program. I urge the full support of the Subcommittee of our FY 1984 budget request.

Thank you.

Responses to written questions from Chairman Volkmer from the February 10, 1983, House Authorization Subcommittee Hearing, at which Mr. Smylie testified.

QUESTION T-1:

Mr. Smylie - Now that the TDRS System is about to be launched let's review the program for a moment.

(a) How much of a cost overrun has the program experienced?

(b) What has caused this growth?

(c) How much has the program grown in the past 12 months?

(d) When will TDRSS be utilized 100% of the time?

(e) What will be the projected operations cost per year?

(f) What are the Federal Financing Bank annual payments for TDRSS?

ANSWER T-1:

(a)&(b) The amount TDRSS has grown can be summarized as follows:

	ORIGINAL	NOW	% CHANGE
Cost/Profit	$ 535M	$1,099M	105%
Inflation	-	87M	N/A
Interest	220M	1,017M	362%
Delay	-	186M	N/A
Launch Vehicle (Shared)	63M	165M	162%
TOTAL	$ 818M	$2,554M	212%

This growth has occurred for four basic reasons:

Delay of program caused by Shuttle slips; increase in economic cost due to excess inflation and interest cost; increases in the cost of launch; and programmatic reasons. Of the programmatic (cost/profit) increase, $164M is attributable to the restructuring of the TDRSS contract to dedicate the system to the support of space missions, and $81M results from the decision to make modifications to secure the system. The remainder are changes that represent cost growth more normally attributed to programs. This $319 million represents a growth of approximately 55 percent.

(c) During the past 12 months, the cost of TDRSS has grown by $228M or 9.8%. This increase is based predominantly on the restructuring of the TDRSS contract which will dedicate TDRSS to support of space missions increasing the operability and flexibility of the system. NASA will gain an additional 1-2 spacecraft which can be used to augment the system capability or extend the system lifetime.

(d) After acceptance of service by NASA in the fall of 1983, TDRSS will be used nearly 100% of the time in support of already inflight spacecraft such as Landsat-D, Solar Mesosphere Explorer (SME), Solar Maximum Mission (SMM) and periodic Shuttle flights. This, however, does not mean that all of the TDRSS communication links will be operating at 100% capacity.

It is impractical to design a system that reaches capacity during the early phases of its lifetime. TDRSS was designed to provide service into the 1990's at which time its usage should be maximized.

(e) It is estimated that the effort associated with operation of the TDRSS at the White Sands Ground Terminal will average approximately $18M per year.

(f) Federal Financing Bank annual payments for TDRSS are projected as follows:

FY 1983	$ 30.1 million
FY 1984	196.7 million
FY 1985 and subsequent years	210.8 million

QUESTION T-2:

With the closing in FY 1984 of several ground stations, how much of a savings do you expect to realize in FY 1985?

Have all the proper people been notified of these potential closings?

ANSWER T-2:

With closure of the Spaceflight Tracking and Data Network (STDN) stations in early 1984, we expect to save about $25M in the STDN in FY 1985. Notification of potential closings has been continually communicated over the last few years in briefings and correspondence with other interested Government Agencies (Defense, State, Commerce), foreign governments through the U. S. Embassies and our contractor personnel.

QUESTION T-3:

Do you anticipate additional station closings in FY 1985 and on?

ANSWER T-3:

The STDN facilities at Madrid, Spain; Canberra, Australia; and Goldstone, California; will be consolidated with the Deep Space Network (DSN) beginning in 1984. This will allow closure of the STDN facilities in Madrid and Australia by February 1985, and the integration of one link of the Goldstone station into the DSN complex.

QUESTION T-4:

In FY 1984, how much money do you plan to spend in preparation for the Space Telescope mission?

ANSWER T-4:

In FY 1984, the Space Tracking and Data Systems budget provides approximately $10.6 million dollars to continue the ongoing ground system development activities for the Space Telescope mission.

QUESTION T-5:

Mr. Smylie - In your prepared testimony, you speak of the new Program Support Communications Network.

(a) How much of the Communications budget is tied up in this?

(b) Is this going to be the annual cost?

(c) Why don't the program offices contribute to this cost?

(d) Where is the program management responsibility for this network? NASA Headquarters or at Goddard?

ANSWER T-5:

(a) The FY 1984 budget for Program Support Communications (PSC) is $13M.

(b) Costs for Program Support Communications are projected to increase to over $20.0 million by FY 1988 (in real year dollars).

(c) In the past, each program office funded its own portion of the PSC costs. However, in FY 1984, OSTDS will assume the overall management and funding of PSC. This action will assure more efficient and effective management and resource control.

(d) The George C. Marshall Space Flight Center (MSFC) has the program management responsibility for Program Support Communications.

QUESTION T-6:

In the budget backup books to support your annual request, you have two Data Processing Requests, one for systems, one for operations.

(a) Could you explain these differences?

(b) Why is the increase of $3M in systems and operations required?

(c) Why don't the program offices pay for their own data processing?

ANSWER T-6:

(a) In the Office of Space Tracking and Data Systems (OSTDS) budget, the lines entitled Systems Implementation include all non-recurring costs for the particular support activity. These costs include hardware and software development, test and integration, documentation, and operator training. These non-recurring costs most generally cover those activities occurring before launch.

The budget line items entitled Operations refer to the recurring or post-launch activities. Typical costs include contractor maintenance and operations personnel salaries, logistics, and software maintenance charges.

(b) The increase of $3M in Systems is approximately $1.3M for escalation and the remainder is to initiate implementation of a data processing system for the Gamma Ray Observatory (GRO).

The increase in Operations is $1.7M for escalation and the remainder is due principally to the full year operation of the Spacelab Data Processing Facility which is currently under development and will be ready for the first Spacelab mission in late 1983.

(c) There are occasions when program offices do pay for their own data processing activities. The most recent example of that is found with the Landsat-4 program where the Space Science and Applications program funded the complete development and implementation of the image data processing system. In the majority of instances, however, processing for the low Earth orbit spacecraft have been done in an institutionalized facility funded by the Space Tracking and Data Systems budget. These facilities typically support several mission and, therefore, are more cost effective than dedicated facilities except for large p rograms such as Landsat-4.

QUESTION T-7:

With the advent of the TDRSS activity and all the new support facilities plus consolidations, why does the Advanced Systems area continue to grow?

ANSWER T-7:

The Advanced Systems Program remains at the same level of effort in FY 1984 as in FY 1983. Increased funding allows for inflation only and maintains the effort at a modest 2% of the overall OSTDS program.

This program forms the backbone of our ability to make necessary performance improvements and operational efficiencies to support new missions. Virtually every phase of our support capability and improvements have been either initiated, studied, or demonstrated in our Advanced Systems Program prior to operational use.

We do not expect that requirements for our Advanced Systems Program effort will diminish. Instead, we know from long experience that the need for technology studies, developments, demonstrations and operations efficiencies will continue as our efforts to improve performance and lower operations costs make use of more complicated technologies.

Mr. VOLKMER. Thank you very much, Mr. Smylie.

Mr. Walker, do you have any questions of Mr. Smylie?

Mr. WALKER. Thank you, Mr. Chairman.

What is the employment level at the various tracking stations presently?

Mr. SMYLIE. I believe our total overall contractor employment for all space tracking and data systems activities is around 5,800.

Mr. WALKER. Is there a significant difference between any of the stations in terms of employment levels?

Mr. SMYLIE. Yes, sir, there is. The stations have varying numbers of antennas at each of them. Some operate 24 hours a day, 7 days a week, while others only operate 1 shift, 5 days. So, there is substantial variation in the employment.

The operations personnel within the stations, counting the 15 or 16 or so stations amount to about 1,300 people. The number, I gave you earlier includes all the network support personnel and the DSN. Total contract employment within the network is 5,843. But the number actually located on site in the ground networks stations not including the DSN, is about 1,000.

Mr. WALKER. I have been at two of the stations, in Madrid and Canberra. Those are essentially similiar operations it looked to me. Are they not?

Mr. SMYLIE. Yes, sir, they are.

Mr. WALKER. Are the employment levels at those two roughly similiar then?

Mr. SMYLIE. I believe the employment in Australia is somewhat less than that in Spain.

In the DSN operations, there are about 150 people in Madrid and about 90 in Australia. The Spanish station has a higher level of employment.

Mr. WALKER. Why would that be?

Mr. SMYLIE. Part of it is related to the labor situation in those two countries, and the long-term operation of those stations. It is a difficult question to answer because part of it has to do with just the labor situation in those countries that we have dealt with over the years.

Mr. WALKER. The reason I asked the question is because my impression, after being at the two stations, was that there is considerably greater employment for similar operations in the station at Madrid than there is in Australia. But my real question is: Is that sort of thing taken into account when you go to consolidation of these stations; if in fact you do have labor situations which are resulting in rather significant increases in employment is that one of the things that is taken into account when you decided, for instance, to keep the Madrid operation in place?

Mr. SMYLIE. We will move an antenna in Madrid and consolidate that station; and when we do that the employment would change drastically. It will probably change a little less drastically in Australia when we do that. But, yes, sir, that was taken into account. We have a very large capital investment in those two places, and they are geographically important to us.

So, it is necessary to maintain those facilities in those countries.

Mr. WALKER. Fine. Can you tell me then what the employment level will be over the 5,800 figure that you gave me; what the employment figure will be overall after consolidation?

Mr. SMYLIE. We will have to provide that for the record, sir.

Mr. WALKER. I would appreciate that.

[The information follows:]

The earlier discussion centered on overall contractor employment for all Space Tracking and Data Systems activities. The area being addressed here is related to the manning level of the NASA ground network which includes the Deep Space Network (DSN) and the Spaceflight Tracking and Data Network (STDN).

The manning level at the ground network in FY 1983 is approximately 1,530. After the network consolidation program is complete, the level at the ground network will decline to approximately 875, when only the following stations will be open: Bermuda, Greenbelt, Merritt Island, Goldstone, Madrid, and Australia.

Mr. VOLKMER. Mr. Bateman.

Mr. BATEMAN. No questions.

Mr. VOLKMER. I would like to ask some questions, Mr. Smylie. What was the increased cost to the Government to have the sole use of the tracking and data relay satellite?

Mr. SMYLIE. The restructuring of that contract to fully dedicate it to space missions will cost $216 million.

Mr. VOLKMER. $216 million?

Mr. SMYLIE. Yes, sir.

Mr. VOLKMER. That is a one-time cost, right?

Mr. SMYLIE. Part of it is interest on our loan payments. So the actual payment will spread over a number of years.

Mr. VOLKMER. That is a one-time adjusted cost?

Mr. SMYLIE. That is a one-time adjustment.

Mr. VOLKMER. What was the cost overrun, if any, on the TDRSS eliminating that $216 million?

Mr. SMYLIE. In terms of cost growth in the program as compared to overrun which is a procurement term, the program cost growth has gone from about $800 million to about $2.5 billion; $2,550,000,000 or so is our estimate in this year's budget including the $216 million for the contract. The percentage increase associated with that restructuring would be about 200 percent cost growth in the program.

Mr. VOLKMER. What was the cause of the cost growth?

Mr. SMYLIE. Several factors. Part of it is just requirements, new technical requirements that we had to meet to have the kind of system required to do the job. This was associated with such things as the change for the radio frequency interference problem that we had, to add more security to the system so that it became a more robust system from a security point of view. The impact of slips in the launch date and so forth. And that amounted to about a 100-percent increase.

The interest cost of the program is the most substantial thing that has happened to us. The original estimate within the $800 million for interest was a little over $200 million; the current estimate for interest on the program is about $1 billion or about a 350-percent increase in interest cost.

The third element was the launch vehicle cost which has gone up about 150 percent. So the elements were technical changes in the program, interest cost increase, launch vehicle cost increases, and the shuttle launch slip.

We originally planned to launch this system in 1979 and we are now launching it in 1983.

Mr. VOLKMER. And the first goes up in March?

Mr. SMYLIE. Yes, sir.

Mr. VOLKMER. The second one in September?

Mr. SMYLIE. The shuttle launch schedule beyond STS-6 has not been firmed up yet, but our expectation is sometime in the summer we will launch the second and early next year the third one.

Mr. VOLKMER. Now we would need the first two up for the spacelab.

Mr. SMYLIE. Yes.

Mr. VOLKMER. And we need 90 days for on-orbit checkout. Are we are going to hit that 90 days from the second TDRS launch to the launch of spacelab?

Mr. SMYLIE. If we maintain the spacelab launch date of September 30, which is highly desirable, then we will not be able to have 90 days between the launch of the second one and the launch of spacelab. So that will squeeze our check-out time. We are currently working to modify our check-out schedule to see if we can accommodate that lesser time interval between the launch of the second and the launch of spacelab.

There are certain things we can do to help that situation. There is some risk involved and we are assessing that now.

Mr. VOLKMER. And it will be fully operational; the TDRSS will be fully operational by fall if everything goes all right?

Mr. SMYLIE. We would commit the system to support spacelab with two spacecraft up. In our terms operational means we will have the third satellite up and checked out which will be early next year. That triggers our ability to begin to close down ground stations. We feel we should have that spare in place before we begin to shutdown ground stations round the world.

Mr. VOLKMER. What are the annual payments to the FFB?

Mr. SMYLIE. Starting in 1984, which is our first full year of payment to the FFB, the payment is about $197 million on that contract.

Mr. VOLKMER. For how long?

Mr. SMYLIE. The payments run for 10 years. In the second year that payment will increase to about $210 million because we will have completed the post construction loan period and then it will run $210 million a year for the remaining term of the loan. The total term of the loan is 10 years.

Mr. VOLKMER. Have the personnel involved in the stations that will be closed out—do they have information on this yet? I suppose it is pretty public.

Mr. SMYLIE. Yes.

Mr. VOLKMER. I mean an official communication.

Mr. SMYLIE. I have talked to personnel, the management, and in some stations the personnel have known about the plans to close for the last several years. So it is well known in all of those locations that those stations will close and when they will close. We are working with our contractors and with the governments in those countries to ease that transition as much as possible.

Mr. VOLKMER. Now in your prepared statement you discuss the new program support communications network. How much of the communications budget total is this part?

Mr. SMYLIE. That program in the 1984 budget is about $13 million.

Mr. VOLKMER. Will that grow in the future?

Mr. SMYLIE. The estimate for that over the next several years is that it will stay fairly close to that in real year dollars. There may be some growth because of new requirements that may come in; but, based on that set of requirements, it should grow only by inflation. We are seeing some inflation in telecommunications costs these days. That is, in the area of competition we are hopeful that some of that may go in the other direction. But in the last year or so we have seen some considerable escalation in costs in telecommunications.

I would expect by the late eighties that number could grow to the $18 to $20 million range, but in real year dollars.

Mr. VOLKMER. Now the program management responsibility for that network, is that in NASA headquarters?

Mr. SMYLIE. Program management responsibility, yes, sir, is in headquarters. The actual operation of that network will be at the Marshall Space Flight Center. Marshall is currently the manager of the teleconferences network that we use for teleconferencing around the agency. We have incorporated the management of this overall activity there, the existing facility and existing people.

Mr. VOLKMER. The responsibility——

Mr. SMYLIE. The program responsibility will be in my office.

Mr. VOLKMER. But actual management of it will be at Marshall?

Mr. SMYLIE. Yes, sir.

Mr. VOLKMER. Now we have also in the budget books two data processing requests, one for systems, one for operations.

Mr. SMYLIE. Yes, sir.

Mr. VOLKMER. Can you explain to me why we need the two different systems?

Mr. SMYLIE. The systems budget is essentially sort of a capital budget to purchase systems for the network, to do the design and the implementation of those capabilities required either to replace systems that have become obsolete or put in place new systems to support a new mission such as the Gamma Ray Observatory Mission. The operations part of the budget is to accomplish the day-to-day operations of those facilities in support of ongoing missions.

It is just a difference in the use of the money carried in those budgets.

Mr. VOLKMER. Now, on the stations that will be closed, let's get back to those; the various equipment, discs, et cetera, that are there, what is going to happen to that equipment?

Mr. SMYLIE. Many of those stations will be taken over and operated by other U.S. Government agencies. In those cases where the excess equipment is to our ongoing requirements which really would be most of it, it will just be left there for the use of those other agencies.

Mr. VOLKMER. Declared surplus.

Mr. SMYLIE. Yes, sir. In foreign countries, equipment that is not required for our ongoing operation of other facilities at other places will be offered to those countries for any ongoing use they may have of that equipment and those facilities, again through an existing surplus process.

Mr. VOLKMER. In other words, if Chile wanted to take that over equipment of Santiago you would say, OK, here.

Mr. SMYLIE. Yes, sir. We would attempt in every way to make arrangements for them to take over and continue to operate those facilities for their own purposes, if they were consistent with space exploration interests. If we need any of that equipment to replace equipment somewhere else in the network, we would bring it back and use it for that purpose. Since we are closing all of these stations of this type, it is likely we would not find any ongoing requirement for it. Most of it is fairly old hardware.

Mr. VOLKMER. I have no further questions. Does anyone else?

Thank you very much, Mr. Smylie. We appreciate your testimony here today and your assistance.

Mr. VOLKMER. Our next witness is Dr. Jack L. Kerrebrock, Associate Administrator, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration; and Dr. Colladay and Mr. Nysmith.

Your statement of course will be part of the record. You may either summarize or review your whole statement, however you see fit.

[A biographical sketch of Dr. Kerrebrock follows:]

DR. JACK L. KERREBROCK

Dr. Jack L. Kerrebrock was named Associate Administrator for Aeronautics and Space Technology at NASA Headquarters July 1, 1981. He is responsible for NASA's aeronautics and space technology as well as energy research programs. Before coming to NASA, Kerrebrock was head of the Department of Aeronautics and Astronautics at the Massachusetts Institute of Technology from 1978.

Dr. Kerrebrock has taught and conducted research in energy conversion and propulsion since 1956 when he received his Ph.D. from the California Institute of Technology, Pasadena. He received his bachelor's degree from Oregon State University, Corvallis in 1950 and his master's degree from Yale University, New Haven, Conn., in 1951. He was an aeronautical research scientist at Lewis Research Center, Cleveland, Ohio, for the National Advisory Committee on Aeronautics, NASA's predecessor, from 1951 to 1953.

His early work was on nuclear rockets, space propulsion and space power, and magnetohydrodynamic generators. More recently, he has been involved with the fluid mechanics of turbomachinery for aircraft engines and gas turbines. He was the director of the MIT Gas Turbine Laboratory from 1968 to 1978 and was the first to hold the Richard Cockburn MacLaurin Professor of Aeronautics and Astronautics post, established in memory of MIT's sixth and youngest president.

Dr. Kerrebrock is a fellow of the American Institute of Aeronautics and Astronautics, and a member of the National Academy of Engineering. Prior to accepting the NASA position, he was a member of the Air Force Scientific Advisory Board; the National Research Council's Aeronautics and Engineering Board; and the NASA Aeronautics Advisory Committee.

Born in Los Angeles, Calif., Kerrebrock and his wife, Vickie, reside in Arlington, Va. They have two children.

STATEMENT OF DR. JACK L. KERREBROCK, ASSOCIATE ADMINISTRATOR, FOR AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION; AND DR. COLLADAY, DEPUTY ASSOCIATE ADMINISTRATOR AND MR. NYSMITH, ASSISTANT ASSOCIATE ADMINISTRATOR

Mr. KERREBROCK. Mr. Chairman, members of the committee, I am pleased to appear before you today to present the NASA space research and technology program and the associated budget request for fiscal year 1984.

I am accompanied by my deputy, Dr. Colladay, and my assistant, Mr. Nysmith; my division directors are also available to assist in answering any detailed questions you may have which I am not able to deal with. I will submit the written testimony for the record and briefly summarize. Let me say first, Mr. Chairman, that I concur completely with your characterization of the responsibilities of the OAST for the nation's base technology in space and furthermore with your estimate of its importance.

Since the early 1970's, the utility of space has become more and more apparent and the U.S. activities in space have grown rapidly. Now, with a fully operational shuttle offering greater access to space, it is reasonable to expect that growth to continue and even increase in the future. To support and promote that growth, it is increasingly important that an aggressive advanced technology program be directed toward long-term, high-risk research that creates new opportunities and provides the understanding, technical options, and extended capability needed for continued U.S. preeminence in space.

Our proposed space R&T program for fiscal year 1984 is designed to address these important needs. Figure 1 shows the budget request of $133.4 million for the research and technology base and systems technology programs which represents an 11 percent increase over the fiscal year 1983 level. The $4.6 million for standards and practices funds the office of the chief engineer, which is included in our line item. It provides an Agency-wide service. The relative emphases which the space R&T program places on disciplinary and systems research is indicated in figure 4. The R&T base includes the disciplinary areas of materials and structures, fluid and thermal physics, chemical propulsion, space data and communications, controls and human factors, energy conversion, and computer science and electronics. Systems research in spacecraft, platforms, and space transportation focuses on the study of component and subsystem interactions and provides the basis for system trade-off studies.

Program direction and the distribution of resources among the various disciplinary and system elements is guided by a long-range plan for space technology which establishes, within the framework of several key objectives, a number of high priority technical goals. The key objectives (chart A) of the space R&T long range plan relate to maintaining excellence at NASA centers in critical space technologies, assuring full participation of the industrial and aca-

demic space research communities, and maintaining a strong program of research and technology.

NASA's record of contributions stem largely from the capabilities of its field centers, their facilities, and the competent personnel that conduct and manage research and technology programs. OAST has the direct institutional responsibility for the three research centers—Ames, Langley and Lewis—where much of the innovative technology for new space systems is generated. The space flight centers—Marshall, Johnson, and Goddard as well as the Jet Propulsion Laboratory—are also imported contributors to the program; and almost one-half of the R&D funds support research and technology efforts at these centers. For example, JPL provides an outstanding R&T complement to our research centers in areas of guidance and control, sensors and instrumentation, teleoperators, and autonomous systems. Broad and balanced participation is vital to NASA's space R&T program which will increasingly serve as the central focus for the expanding national space activities. Accomplishment of our technical goals cannot, and should not, be addressed by the NASA centers alone. Increased participation by industry and universities is being sought. Centers of technical excellence will be sponsored as one means to this end.

I would like to mention just a few of our significant accomplishments during the past year. We demonstrated operation of a high pressure xenon chloride, magnetically switched laser to extend the spectral range of future remote sensing systems. A Feature Identification and Location Experiment [FILE] on the STS–2 flight proved the concept of onboard processing of earth images for application to earth resource sensing satellites. A power amplifier chip for the 30/20 GHz transmit/receive system was produced, and ground deployment of four elements of a wrap-rib antenna was accomplished. DEVISER, which is a title for an artificial intelligence technique for planetary and earth orbital spacecraft sequencing, was demonstrated in the laboratory.

I also have with me two physical samples of our accomplishments. The first is an advance in flexible thermal protection for application to future earth-to-orbit transportation vehicles. This material is made up of a silica insulator and a back face of fiberglass cloth that has replaced the tiles on some areas of the shuttle surface. The other sample is one of the chips used in our massively parallel processor program. The unique architecture of this chip enables the system to simultaneously process multiple streams of data. That chip is one of many that would be used in the parallel processor, and would enable computer speeds of a billion operations per second, which is 10 to 100 times better than conventional serial processing techniques. We will receive the full processor system from Goodyear Aerospace this spring. It should be in operation this year.

Within the scope of our fiscal year 1984 program, we have identified major thrusts that will strengthen our R&T program. This past year, we initiated a new program in computer science and electronics which will continue to focus computer science expertise and technology advances on aerospace applications in fiscal year 1984.

In fiscal year 1984, a modest expansion to the base program in space station related technology is planned to strengthen the base technologies for a future space station.

In systems technology, an increase is planned in space flight experiments where zero weightlessness and the combination of space vacuum and space radiation environments will enable the development and characterization of many technologies important to future space systems. A major objective of our program [chart B] is to provide a base of proven technology to support the concept and design of future spacecraft systems. Research in advanced sensors aims to extend the spectral range and to increase the resolution of lasers and other solid state devices. Onboard processing of sensor data will enable more efficient selection of useful information for transmission and for adaptive control of mission sequences. Advances in fault-tolerant systems and autonomous operations will lead to improved productivity and increased spacecraft versatility. For example, in the design of Galileo and in the next Voyager encounter with Uranus, a system of automated mission sequencing will be utilized.

Let me explain for the gentleman who just came in, that item is a sample of a new flexible insulation material which will replace the tiles on some surface areas on the shuttle. It is a silica fiber mat covered by a silica cloth and is much more tolerant to damage. It is also much easier to install than the many tiles, as each tile has its own part number.

Mr. VOLKMER. What is the difference in weight per square foot?

Dr. KERREBROCK. I don't really know. We could get that information for you. [See detailed response to question R–4, p. 253.]

Mr. VOLKMER. It is quite a bit less undoubtedly.

Mr. KERREBROCK. The major advantage is the resistance to damage and the ease of installation. The tiles are also light.

Improvements in space transportation technology will lead to lower operating cost to and in space. New, flexible ceramic thermal protection has replaced many tile areas on both the Columbia and the Challenger. High temperature, carbon-carbon composite materials are planned for later incorporation in areas of higher heat load on the vehicles.

Reusable orbital transfer vehicles [OTV] will require advances in propulsion technology to minimize operational costs and to meet the demanding requirements of space maintainability, throttling, and high performance. Aeroassist techniques will allow OTV penetrations into the atmosphere to reduce propellant requirements. The ability to store and efficiently transfer cryogenic fuels for OTV's remains to be developed.

The flight experiments program is proving to be a very cost effective means for the conduct of research in the real space environment. Shuttle-based experiments have included measurements of the thermal, dynamic, acoustic, and particle contamination environments in the shuttle bay, all of which are very important to the designers of payloads to be carried in the shuttle.

The orbiter experiments program [OEX] will take advantage of the shuttle orbiter as a flight research vehicle to generate fundamental knowledge in entry aerodynamics, aerothermodynamics,

and materials behavior that will be used to improve both current and future transportation systems.

In fiscal year 1984, OAST will undertake the design of two low cost, reusable, in-space experiment carriers. These are a large structures and controls experiment and a cryogenic fluid management facility.

Space station related technologies will be enhanced to support the Agency goal of a permanent presence in space, including work in large space systems, energy conversion, controls, and human factors. Research in high capacity electrical power systems is required to achieve the multihundred-kilowatt energy systems required for space stations. Maintaining the stability of large space systems requires new concepts for control, such as distributed and adaptive control techniques. Fully exploiting the capabilities of humans through teleoperations will require a better understanding of the interface between human and machine.

I would like to emphasize that most of the technologies addressed by the NASA program have common applicability to civil, commercial, and military needs. Providing the Nation with the technology base to support continued U.S. leadership in space requires that we understand the needs not only of the other program offices in NASA, but also of satellite manufacturers, commercial satellite users, and the military. Consequently, OAST interacts extensively with this community in planning, coordinating, and conducting its program. This, of course, includes coordinating with the new Air Force Space Technology Center to insure the broadest possible cooperation between the DOD and NASA. Industrial involvement in planning is being expanded through reviews of NASA space technology planning and company independent research and development [IR&D] programs. The academic community assists us in maintaining program currency and breadth. Through this process of interactive planning, synergistic programs are fostered and duplication of effort is minimized.

The few highlights covered today represent only a sampling of the very comprehensive research and technology program conducted by OAST in support of the Nation's space activities. I wish to underscore my conviction that the proposed fiscal year 1984 program is, indeed, vital to the goal of maintaining U.S. preeminence in space.

Mr. Chairman, I would like to close with a few words about our energy programs, for which my office is responsible.

In fiscal year 1984, NASA plans to continue support for ongoing energy programs that the DOE or other sponsoring agencies request NASA to continue. Previous commitments will be completed as efficiently as possible to insure the integrity of the Government investment made to date. For the future, energy research will be focused on programs that have common objectives with our aeronautics and space programs. To effectively implement this policy, the Lewis Research Center has reorganized the management of energy programs to promote closer relationships between energy research and that in aeronautics and space.

That completes my formal statement. Thank you.

[The prepared statement, plus answers to questions asked of Dr. Kerrebrock, follows:]

HOLD FOR RELEASE
UNTIL
PRESENTED BY WITNESS
FEBRUARY 10, 1983

STATEMENT
OF
Dr. Jack L. Kerrebrock
Associate Administrator for
Aeronautics and Space Technology

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I am pleased to present to you the proposed NASA Space Research and Technology (R&T) Program and the associated budget request for FY 1984.

There has been considerable progress made in a number of important areas in the program over the past year and we have embarked on several new and promising research thrusts which I will be describing.

Since the early 1970's, the utility of space has become more and more apparent and the U.S. investment in space activities has grown rapidly. Now, with a fully operational Shuttle offering greater access to space, it is reasonable to expect that growth to continue and even increase in the future. To support and promote that growth rate, it is increasingly important that an aggressive advanced technology program be directed towards long-term, high risk research that creates new opportunities and provides the understanding, technical options, and extended capability for continued U.S. preeminence in space.

The FY 1984 Space R&T budget request supports a program structured to meet high priority commitments to: (1) provide a base of proven

technology supporting the conception and design of future spacecraft, (2) continue development of space transportation technology for improving low cost access to space, (3) extend ground-based research and technology activities into the space environment, (4) support a permanent presence in space, and (5) support the projected long-term base R&T needs of military and commercial use of space.

The FY 1984 budget request is shown in Figure 1 and compared with the FY 1982 and FY 1983 budgets. The total request of $138 million includes $4.6 million for Standards and Practices. This element, which provides for the necessary agency-wide support from our Office of the Chief Engineer, is not addressed in this testimony. Within the Space R&T budget, the major emphasis continues to be in the Research and Technology Base activities, illustrated in Figure 2. The R&T Base includes the disciplinary areas of materials and structures, space energy conversion, computer science and electronics, chemical propulsion, controls and human factors, fluid and thermal physics, and space data and communications. Also included is systems research in transportation, spacecraft, and space platforms which focuses on the study of component and subsystem interactions and provides the basis for system trade-off studies.

This past year, we initiated a new program thrust in computer science which will continue in FY 1984 to focus computer science expertise and technology advances on aerospace applications. In FY 1984, a modest expansion to the base program in space station related technology is planned to further investigate promising high leverage technologies that could greatly enhance the capabilities for future space station configurations. In Systems Technology, an increase is planned in space flight experiments where zero gravity and the combination of space vacuum and space radiation environments are necessary to the development and characterization of many technologies important to future space systems.

Program direction and the distribution of resources among the various disciplinary and system elements is guided by an Office of Aeronautics and Space Technology (OAST) Long Range Plan for Space Technology which establishes, within the framework of several key objectives, a number of high priority technical goals. The key objectives of this Long Range Plan are to:

- Provide U.S. R&T capability by maintaining undisputed technological excellence at NASA Centers in critical space technology areas.

- Assure participation in the Space R&T program by NASA Centers, government agencies, universities, and industrial research organizations.

- Strengthen the NASA Space R&T program to ensure the timely provision of new concepts and advanced technology for the U.S. civil and military space activities.

A primary strength of NASA has been the institutional capability represented by its Research Centers, Ames, Langley, and Lewis, and the Space Flight Centers, Goddard, Johnson, Marshall, and the Jet Propulsion Laboratory. OAST has the direct institutional responsibility for the three Research Centers and supports the Flight Centers in areas essential to attainment of the technical objectives of the program. The spectrum of capabilities and expertise provided by each of the Centers is shown in Figure 3 along with the funding distribution by Center.

The high priority technical goals for the Space R&T program are formulated against a scenario of the future which has orbiting systems transitioning from a large number of free flyers to consolidated, autonomous platforms and clusters; a planetary exploration program made possible by lower cost technology innovations; and transportation systems providing lower cost access to space with improved and derivative Shuttle vehicles, reusable orbital transfer vehicles, and an aeromaneuvering orbit-on-demand capability. Capabilities that will be required if this view of the future is to be realized are high voltage, high capacity power systems; distributed and adaptive controls for large space structures; high data rate systems with on-orbit processing and direct user access; long life propulsion; autonomy; and teleoperator technology.

I would like to address selected high priority technical goals in these areas, discussing recent accomplishments, FY 1984 plans, and long range objectives. The funding distribution by budget category is shown in Figure 4 along with call-outs depicting the principal thrusts of the technology area.

ADVANCED SENSORS - The overall objective of the advanced sensor program is to provide new technology that exploits the unique properties of lasers, extends the capabilities of microwave tubes, and advances infrared detectors for passive and active sensing of terrestrial, planetary, and galactic environments. An advanced sensor concept for laser detection and ranging, called LIDAR, is shown in Figure 5. It uses a narrow energetic beam to provide information on range, atmospheric species concentration, and wind speed. Recently, a laser system with appropriate duty cycle, durability, and proper frequency and energy content was developed. NASA scientists at the Jet Propulsion Laboratory demonstrated the world's first high pressure version of a compact, 1 to 10 watt, xenon chloride laser capable of repetitive operation at 10 to 100 Hz. This laser configuration, incorporating advanced magnetic switch technology which promises to increase the efficiencies of electron pumped lasers, will be further investigated in FY 1984. Eventually, the laser will be flight qualified in a spaceborne LIDAR system.

INFORMATION MANAGEMENT - Improvement of information management for future space data systems will provide more efficient and effective data transfer from sensor to user and aid in sensor control by a distributed body of users. The recent FY 1982 demonstration of high speed data preprocessing, Figure 6, has extended the onboard processing capability initially demonstrated on the second Shuttle flight as part of the Feature Identification and Location Experiment (FILE). This experiment provided verification of advanced concepts for high rate information processing and adaptive sensor control to increase the useful content of multispectral imaging applications. Activities for FY 1984 will be directed at development of new concepts and architectures for adaptive, fault-tolerant onboard data systems with significant improvements in data processing and storage leading to a very small, general purpose flight computer.

TECHNOLOGY FOR SATELLITE COMMUNICATIONS - Advances in communications technology will provide enhanced distribution of processed data needed to meet anticipated increases in communications service demands for high rate Shuttle payloads, spacecraft, and platforms. Ongoing research in beam antenna technology at the Lewis Research Center is focused on the development of monolithic microwave

integrated circuits (MMIC) and the investigation of candidate antenna configurations which will use this technology (Figure 7). The MMIC efforts include developing 20 gigaHertz (GHz) variable power amplifier and phase control transmit modules, and a 30 GHz receive module. In FY 1984, OAST will emphasize the development and testing of experimental models of 20 GHz transmit and 30 GHz receive antenna systems, supporting the design, development, and demonstration of a multispot and scanning beam antenna system.

LARGE ANTENNA SYSTEMS TECHNOLOGY - Large deployable antenna systems in geostationary orbit will complement existing communications networks and provide communications service for extensive areas of the earth. As part of the development of Lockheed Missile and Space Company's offset wrap rib deployable antenna concept, shown in Figure 8, four ribs, the hub, and deployment mechanism for a 50-meter diameter antenna have recently been fabricated and assembled. In FY 1983, the antenna reflective mesh surface will be fabricated, attached to the ribs, and ground tested. Since a smooth wrinkle-free surface is critical to the performance of these large antennas, effects of packaging and deployment on the surface will be characterized. In FY 1984, a large antenna technology in-space experiment will be defined to verify advanced structures/controls interaction models which can only be investigated adequately in the gravity-free vacuum of space. The objective is to flight test an antenna structure in FY 1988 onboard the Shuttle.

TECHNOLOGY FOR DISTRIBUTED AND ADAPTIVE CONTROLS - Distributed and adaptive controls designed to maintain stability of large space systems will become essential as these systems become larger and more flexible. Conventional techniques used to control systems with unknown or changing parameters could allow such systems to become unstable. Ongoing research is focused on identifying and estimating the parameters needed to control large space structures. Ground experiments demonstrating the application of distributed and adaptive control on a structural beam are illustrated in Figure 9. As expected, a conventional filter did not damp, or control, the instability of the structure following an impulse disturbance; however, the adaptive filter did correct the error and effectively damped out the system. By the end of FY 1984, this controls research will be extended to multiparameter adaptive control of a more complex structure. The techniques will be verified in

future space flight experiments and could be applied to large manned and unmanned platform systems.

HIGH CAPACITY ELECTRICAL POWER SYSTEMS - Research in space energy conversion offers the potential for increased power production with large cost and system weight reductions for spacecraft in the late 1980's. Energy storage technology, which is a key to attaining the desired mass, reliability, and life of high capacity space power systems, is focused on determining the feasibility of battery and fuel cell/electrolysis systems for multihundred-kilowatt orbital energy storage. Earlier in FY 1983, a high capacity, light weight nickel-hydrogen bipolar battery, shown in Figure 10, underwent a successful preliminary demonstration at Lewis Research Center. In FY 1984 another concept, a breadboard system of a hydrogen/oxygen fuel cell electrolyzer, will be evaluated in a cooperative effort between Lewis Research Center and Johnson Space Center.

Research in energy conversion and systems applicable to a nuclear reactor heat source is investigating advanced concepts for greater power and increased capacity. A joint program in space nuclear reactor technology is being formulated between NASA and the Departments of Defense and Energy to continue development of critical technologies leading to a demonstration of a 100-kilowatt-class reactor power subsystem in the 1990's.

TECHNOLOGY BASE IN COMPUTER SCIENCE - Following a comprehensive assessment of NASA computer science research needs, a program designed to focus computer science expertise and technology advances on aerospace applications was initiated in FY 1983. The program is organized around three themes indicated on Figure 11: highly-reliable cost-effective computing, concurrent processing, and scientific and engineering information management. In FY 1984, the Jet Propulsion Laboratory, building on a technology foundation developed jointly by NASA and the Defense Advanced Research Projects Agency (DARPA), will extend Large Scale Integration/Very Large Scale Integration (LSI/VLSI) research to develop circuit design principles and techniques for fault-tolerant space qualified computers. This effort will provide the insight needed to test and verify these devices when fault-tolerant logic is built into the chip.

Research on techniques for management and

processing of massive amounts of information offers very large potential benefits that could be realized from increases in the efficiency of aerospace computing. Research in FY 1984 will focus on architectures, models, and access methods for managing high volume, geographically distributed scientific data bases.

TECHNOLOGY BASE FOR AUTONOMOUS SYSTEMS - Advances in teleoperator and autonomous space systems technology could substantially increase the overall level of capability for unmanned space science experiments and for autonomous operations on the Shuttle or a space platform, and could decrease the dependency on extensive ground control operations now being used. In FY 1982, major progress was made toward this goal using artificial intelligence techniques in a computer program called DEVISER, illustrated in Figure 12. Automated sequence planning for a simulated Voyager spacecraft encounter with Jupiter provided a productivity improvement of at least a factor of four over the traditional manual approaches. Based on this demonstration, DEVISER will be used for the Voyager encounter with Uranus in 1986, and for constructing spacecraft sequences for the Galileo Probe.

Investigations of a conceptual model providing rudimentary autonomy for operations planning, fault detection and diagnosis, and operations monitoring, will continue in FY 1984. It is anticipated that this research will lead to the improved productivity and increased spacecraft versatility required for higher capability, cost effective missions of the 1990's.

TECHNOLOGY BASE FOR HUMAN CAPABILITY IN SPACE - Fully exploiting the complementary abilities of automation and humans presents a new challenge that will greatly enhance our capability in space. Extended human capabilities will depend on teleoperations and a better understanding of the interface between human and machine. Although current technology for teleoperation in space is limited to the Shuttle's Remote Manipulator System, recent laboratory simulations, as illustrated in Figure 13, indicate that technology could support the development of a teleoperator with capabilities equivalent to a suited astronaut for some satellite servicing tasks. Langley Research Center in FY 1984, with contractor support from Martin Marietta Corporation, will complete construction of a simulator for evaluating remote manipulator man-machine interfaces.

MATERIALS AND CONCEPTS FOR ORBITER THERMAL PROTECTION - Advanced concepts and new materials for improved thermal protection systems (TPS) will enable mission cost reductions, increased payloads, and extended mission capabilities. Although the current ceramic tile performs well for the Shuttle ascent and reentry loads, further improvements in durability, life, and strength are under study. Over the past few years, Ames Research Center, working with the Johns Manville Corporation, has developed a new flexible ceramic TPS, called AFRSI, a quilted sandwich of silica felt and glass fabric, shown in Figure 14. This material, which is a suitable replacement TPS in regions operating at less than 1200-degrees Fahrenheit, was used in 1982 as a retrofit to the elevon cove area on the Columbia; it is also installed on the Orbital Maneuvering System (OMS) pods on the Challenger. The material will be applied extensively to Discovery, covering much of the upper surfaces of the wings and the fuselage sidewalls and tail. In FY 1984, Langley Research Center, in close cooperation with the Vought Corporation, will continue development of advanced carbon-carbon composite materials and concepts for high temperature, high strength applications to large underside areas of advanced vehicles.

LONGER-LIFE, REUSABLE ENGINES - Long-life, reusable liquid rocket engines play a key role in minimizing the cost of space operations. During FY 1982, emphasis has been on rotating parts of the high speed turbopumps, and on bearing life using the Shuttle Main Engine as representative of the state-of-the-art. Basic understanding of the loads imparted to the bearing by rapid start-up transients, by rotor dynamics, and by other generated forces such as rubbing and fluid flow, is being acquired (Figure 15). In addition, analytical models to predict the hot gas environment in which the parts must operate are being explored, and this effort will continue in FY 1984. Diagnostic instrumentation techniques for monitoring engine status and detecting incipient failure have been developed. Experimental validation of components, techniques, instrumentation, and modeling tools will lead to a technology data base suitable for application to advanced propulsion systems for Shuttle enhancement and future space transportation systems.

TECHNOLOGY FOR OTV PROPULSION AND TANKAGE - Advances in propulsion technology will be needed to meet the demanding requirements of possible future reusable orbital transfer vehicles (OTV).

Propulsion, aeroassist, and space refueling technology capabilities can significantly enhance vehicle operational flexibility, Figure 16. Advanced propulsion technology will require reusability, space maintainability, throttleability, and high performance. Progress to date has provided conceptual designs, and the initiation of a test program to demonstrate engine component life and performance.

In aeroassist technology, several vehicle concepts have been evaluated and requirements for controls and aerobrake materials have been identified during the past year. In FY 1984, experimental evaluations will be conducted at simulated flight conditions on aerobrake material durability, and adaptive control techniques will be evaluated through analysis and laboratory tests.

The storage and transfer of cryogenic fluids in space will be essential to the operation of orbital transfer vehicles. As part of the program, fluid transfer, fluid dynamic and thermodynamic fundamentals, tankage concepts, and insulation systems are being explored. Flight experiments, essential to the ultimate validation of these technologies, are being defined and are planned to be flown in the late 1980's as part of the Cryogenic Fluid Management Test Facility.

COMPUTATIONAL FLUID DYNAMICS TECHNIQUES - A primary requirement in the development of high performance aerospace vehicles is the accurate prediction of flowfield characteristics. Consequently, current efforts are focused on developing and validating computational fluid dynamics (CFD) techniques for the regimes of ascent to orbit, low-earth orbit, and entry. In FY 1982, CFD methodology was successfully applied to generate adaptive grid codes for computing flow vectors through the complete flowfield of the Galileo Probe, illustrated in Figure 17. The emphasis in FY 1984 at both Ames and Langley Research Centers will be on expanding predictive techniques to three dimensional analyses of a broad range of flow regimes. Rarefied-flow benchmark prediction techniques for vehicles operating in low-earth orbit and the upper atmosphere will be developed at Langley Research Center, in conjunction with Old Dominion University and the University of Sydney. The major objective for the next few years will be to extend the application of current CFD techniques to complete trajectories of vehicles, including space platform, aeroassisted OTV, and aeromaneuvering orbit-on-demand configurations.

FLIGHT EXPERIMENTS PROGRAM - Routine access to space now provides the capability for the logical and systematic extension of research from the ground-based environment to that of space. The development of technologies, such as large flexible structures, antenna shape control, and fluid transfer, requires various combinations of low gravity, vacuum, and radiation environments. Such combined conditions are difficult and costly to simulate on earth; however, they are readily available in space.

Several important experiments were flown on the Shuttle in the past year and more are scheduled in FY 1984 (Figure 18). The Induced Environment Contamination Monitor provided data which characterized the particulate and molecular environment of the Shuttle bay. The Thermal Canister Experiment provided a technology verification for the precise thermal control of sensitive instruments in the temperature extremes of the space environment. FILE, which was flown in FY 1982, was discussed earlier. The Orbiter Experiments program has used the Shuttle Orbiter as a flight research vehicle gaining fundamental knowledge regarding entry aerodynamics, aerothermodynamics, and materials behavior. The figure displays a thermal map of the Orbiter windward surface produced from an infra-red image near peak heating conditions.

A wide range of disciplinary and systems experiments are scheduled for flights in FY 1984 and FY 1985, addressing such key technologies as advanced solar arrays, electric propulsion, materials, structures, and lubrication. In FY 1984, OAST will initiate design of a large structures and controls experiment and a Cryogenic Fluid Management Facility, ultimately providing the research community with two low cost, in-space research facilities.

These are some of the highlights of the Space R&T program in terms of recent accomplishments and plans for FY 1984 and beyond. Before concluding, I would like to emphasize that most of the technology advances from the NASA program have common applicability to civil, commercial, and military needs. Consequently, it is extremely important for us to understand the needs not only of the other program offices in NASA, but also of the satellite manufacturing industry, the commercial satellite users, and the military, in order to provide the nation with the technology base to support

continued U.S. leadership in space.

OAST's extensive interaction with the outside community in planning, coordinating, and conducting its program is illustrated in Figure 19. The Aeronautics and Space Engineering Board (ASEB) of the National Academy of Engineering and the Space Systems and Technology Advisory Committee (SSTAC) of the NASA Advisory Council continue to provide valuable advice on program planning. Department of Defense (DOD) coordination and joint program planning is conducted through existing interfaces of the Aeronautics and Astronautics Coordinating Board (AACB) and the Space Technology Interdependency Group (STIG), which involves OAST and the Air Force Systems Command. Improved interfaces are being established with DARPA and the new Air Force Space Command to ensure the broadest possible cooperation between key space elements of the DOD and OAST. Industrial involvement in planning is being expanded through increasing reviews of NASA space technology planning and company Independent Research and Development (IR&D) programs. Academic knowledge and expertise serves to assist the government in maintaining program currency and focus. A knowledge of progress and plans in foreign technology is also being maintained. By virtue of this process of interactive planning, synergistic programs are fostered and duplication of effort minimized.

In conclusion, I would like to summarize the major thrusts that shape our program. Space R&T supports the NASA programs in planetary exploration, astrophysics, solar physics, and earth science. It is moving toward a more comprehensive national role in which it serves commercial, DOD and other government users. Space R&T is also contributing to improvements in space transportation cost effectiveness and capability. OAST has identified critical technologies that could enhance capabilities for a possible future space station. We recognize the unique opportunities to perform cost effective research in orbit generated by the Space Shuttle, and are augmenting the flight experiments program. To improve our understanding and better formulate our policies and programs, we are strengthening communication with all elements of civil, military, and commercial market sectors. OAST has made substantial technology advances in FY 1982, continuing in FY 1983, and is proposing an FY 1984 program aimed at maintaining United States preeminence in space.

ENERGY TECHNOLOGY

And now, Mr. Chairman, I would like to complete my testimony by discussing our energy program, including significant FY 1982 accomplishments, the continuing FY 1983 program, and the plans for FY 1984.

During the past year, NASA continued to support the Department of Energy (DOE) and other federal agencies in energy research and technology development. At the Lewis Research Center, significant progress continued in the development of ceramic component technology for automotive gas turbines. Cold spin tests have shown that the demonstrated strength of ceramic turbine rotors continues to improve. Progress has been made in improving the performance of experimental high temperature, high pressure fuel cell stacks for phosphoric acid fuel cell systems. There has been a small set back in the wind energy program at the Goldendale, Washington installation. Cracks have been detected in the drive shafts of two of the three 2.5 megawatt MOD-2 wind turbines. The cracks were induced by stress concentrations at holes drilled during the assembly process. Normal operations will resume in six to nine months.

In the program with the Department of the Interior, the 4 megawatt, WTS-4 wind turbine, built by Hamilton Standard Company, began operation in August 1982 at Medicine Bow, Wyoming. This is the first large wind turbine designed to use fiberglass blades. At the Jet Propulsion Laboratory, an experimental solar thermal system using a parabolic solar concentrator passed a significant milestone for solar conversion systems; using a Stirling engine at 23 kilowatts, the system operated at an overall system efficiency of 29 percent. Steady progress continues in photovoltaic array research, with the emphasis on providing long life, cost competitive processes and techniques for silicon refinement, silicon sheet growth, and cell and module process techniques.

NASA plans to continue support for ongoing energy programs, that the DOE or other sponsoring agencies request NASA to continue. Previous commitments will be completed as efficiently as possible to ensure the integrity of the government investment made to date. For the future, energy research will be focused on programs that have common objectives with our aeronautics and space programs. This policy is consistent with the Memorandum of

Understanding signed with the DOE and its predecessor, the Energy Research and Development Agency. We have recently discussed these points with senior DOE management and have their concurrence in the value of continuing this relationship. In FY 1984, the programs with strong relationship to the aeronautics and space programs will be implemented primarily using NASA civil service manpower. Other ongoing programs will be conducted primarily by support service contractors.

To effectively implement the NASA policy in energy, the Lewis Research Center has reorganized the management of energy programs. This reorganization will permit closer relationships among the research in aeronautics, space and energy activities and more efficient use of NASA's civil service manpower.

GOAL: CONTINUED PREEMINENCE THROUGH R&T

OBJECTIVES

- MAINTAIN EXCELLENCE AT NASA CENTERS
  - AMES, LANGLEY, LEWIS RESEARCH CENTERS
  - FLIGHT CENTERS
- ASSURE BALANCED NATIONAL PARTICIPATION
  - GOVERNMENT
  - INDUSTRY
  - UNIVERSITIES
- STRENGTHEN R&T PROGRAM
  - BASIC R&T
  - SYSTEMS RESEARCH

NASA

Chart A

OAST

NASA HQ RS83 786 (3)
1 14 83

SPACE R&T PROGRAM FOCUS

- **FUTURE SPACECRAFT SYSTEMS**
  - SENSORS, ON-BOARD PROCESSORS
  - FAULT TOLERANT AND AUTONOMOUS SYSTEMS
  - SPACEFRAME TECHNOLOGIES
- **LOW-COST TRANSPORTATION SYSTEMS**
  - SHUTTLE ENGINE AND TPS LIFE ENHANCEMENTS
  - PROPULSION, AERO-ASSIST AND CRYO-REFUEL FOR OTV CONCEPTS
- **SPACE-BASED EXPERIMENTS**
  - SHUTTLE BAY, SPACELAB AND FREE FLYERS
  - LOW-COST "EXPERIMENT FACILITY" CONCEPTS
- **SPACE STATION CAPABILITIES**
  - LARGE SPACE SYSTEMS, DISTRIBUTED CONTROLS, HI-VOLTAGE/HI-POWER
  - HUMAN CAPABILITIES, TELEOPERATION
- **COMMON NATIONAL SPACE NEEDS**
  - SATELLITE COMMUNICATIONS TECHNOLOGY
  - NASA/MILITARY INTER-DEPENDENCY PROGRAMS

SPACE RESEARCH & TECHNOLOGY

R&D BUDGET ($M)

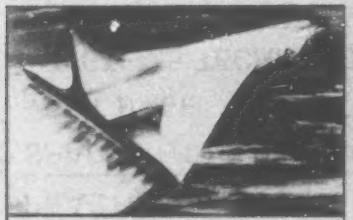
	FY 1982	FY 1983		FY 1984
		BUDGET ESTIMATE	CURRENT ESTIMATE	
TOTAL R&D	111.0	123.0	123.0	138.0
STANDARDS & PRACTICES	3.0	3.0	3.0	4.6
SPACE R&T (SUBTOTAL)	108.0	120.0	120.0	133.4
R&T BASE	104.6	115.6	115.1	126.2
SYSTEMS TECHNOLOGY	3.4	4.4	4.9	7.2

NASA

Figure 1

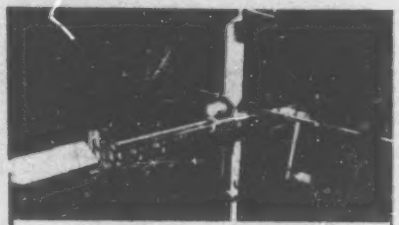
OAST NASA HQ RS83 789 (3) 1 14 83

MAINTAIN UNITED STATES PREEMINENCE IN SPACE



TRANSPORTATION

SPACECRAFT



SPACE PLATFORMS

RESEARCH & TECHNOLOGY FOR NATIONAL SPACE MISSIONS

- MATERIALS AND STRUCTURES
- ENERGY CONVERSION
- COMPUTER SCIENCE AND ELECTRONICS
- PROPULSION
- CONTROLS AND HUMAN FACTORS
- FLUID AND THERMAL PHYSICS
- DATA AND COMMUNICATIONS

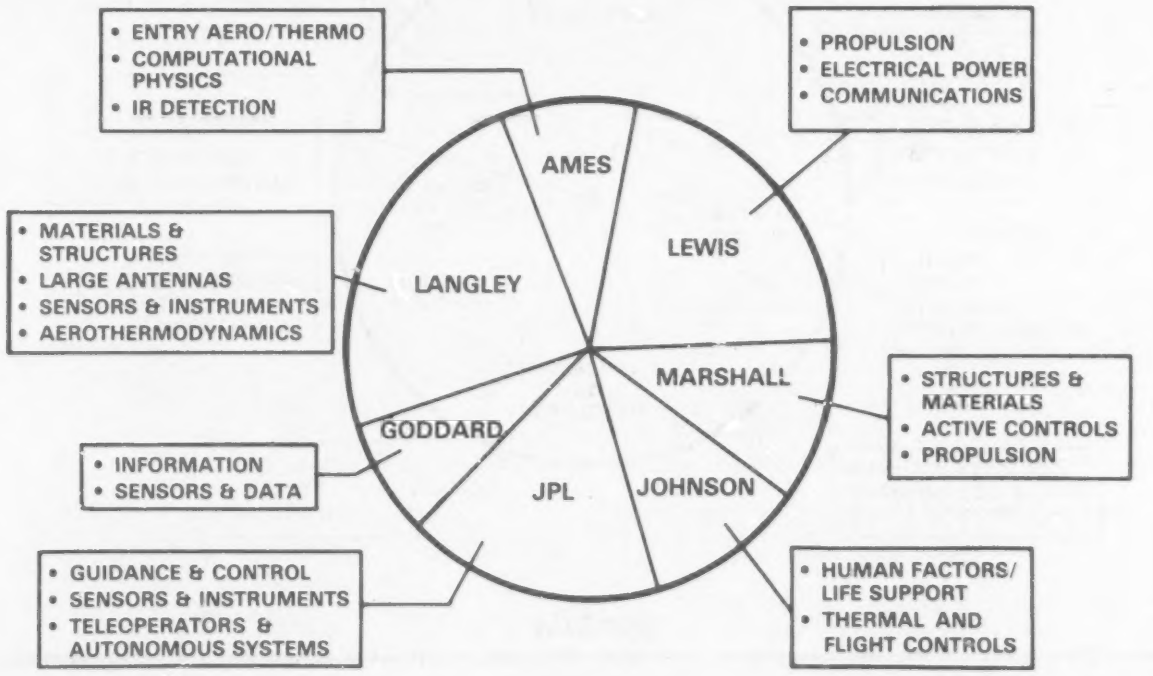
NASA

Figure 2

OAST NASA HQ RS83 783 (3)
1-14-83

FUNDING DISTRIBUTION & ROLES

FY 1984 R&D BUDGET — $133.4M



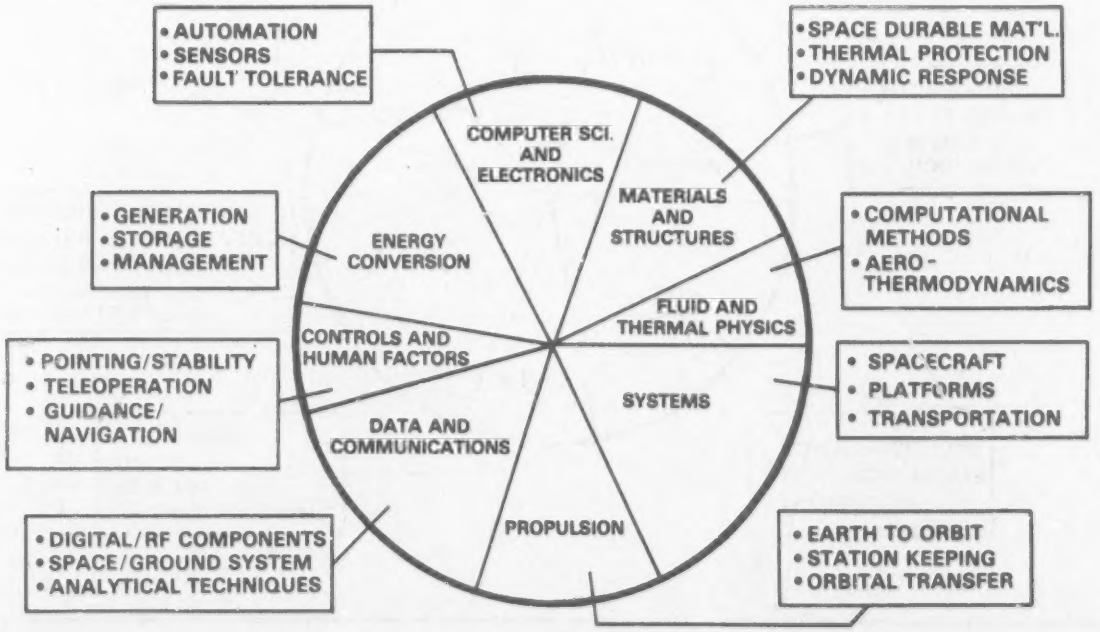
NASA

Figure 3

OAST NASA HQ RS83 788 (3) 1 14 83

FUNDING DISTRIBUTION BY TECHNICAL AREA

$133.4M



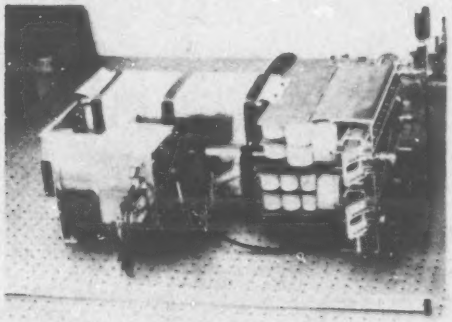
NASA

Figure 4

OAST NASA HQ RS83-799 (3) 1-14-83

ADVANCED SENSOR CONCEPTS

COMPUTER SCIENCE AND ELECTRONICS



- INCREASE ENERGY DENSITY
- LONGER LIFE
- BROADER FREQUENCY

DEMONSTRATE UV AND VISIBLE LASER CONCEPTS – 1982, 1983

ACTIVE LASER RADAR (LIDAR) REMOTE SENSING

SPACE BORNE LASER SENSOR CAPABILITY 1984

NASA

Figure 5

OAST

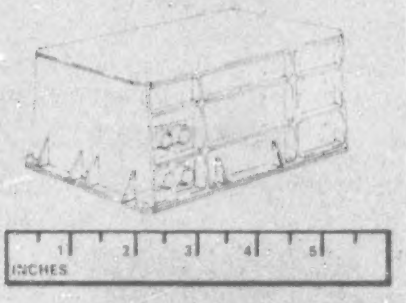
TECHNOLOGY FOR SPACE INFORMATION MANAGEMENT

DATA AND COMMUNICATIONS

ONBOARD DATA PROCESSING

FILE STS-2

- REAL TIME
- LOW-COST TERMINALS
- EARLY SCREENING



GENERAL PURPOSE FLIGHT COMPUTER

INITIAL DEMONSTRATION OF ONBOARD PREPROCESSING – 1982, 1983

CONCEPTS FOR ONBOARD PROCESSOR 1984

NASA

Figure 6

OAST

TECHNOLOGY FOR SATELLITE COMMUNICATIONS

DATA AND COMMUNICATIONS

- ELECTRONIC COMPONENTS
  - SPACE AND GROUND SYSTEMS
    - PROPAGATION PHENOMENA

SINGLE CHIP TRANSMIT/RECEIVE MODULES

MODULE DEVELOPMENT – 1982, 1983

MULTIPLE SPOT AND SCANNING BEAM ANTENNA

ANTENNA SYSTEM DESIGN COMPLETE AND COMPONENTS DELIVERED 1984

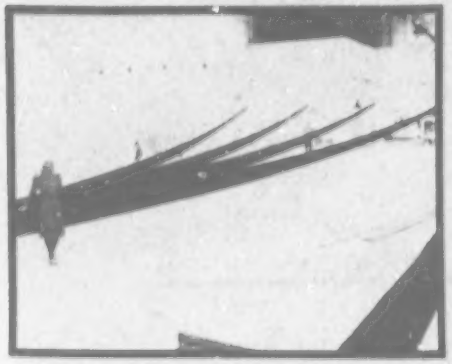
NASA

Figure 7

OAST

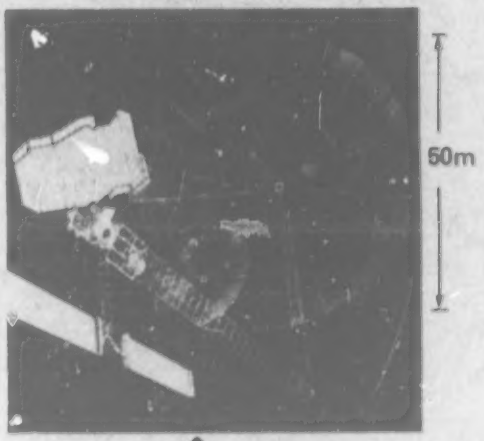
LARGE ANTENNA SYSTEMS TECHNOLOGY

SPACECRAFT SYSTEMS



4 RIB DEPLOYMENT TESTS–
1982, 1983

- MOBILE COMMUNICATION
- SCIENCE
- EARTH OBSERVATION



STRUCTURES AND CONTROLS MODELING
1984

SHUTTLE FLIGHT
1988

NASA

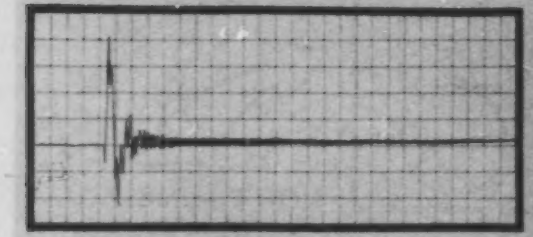
Figure 8

OAST

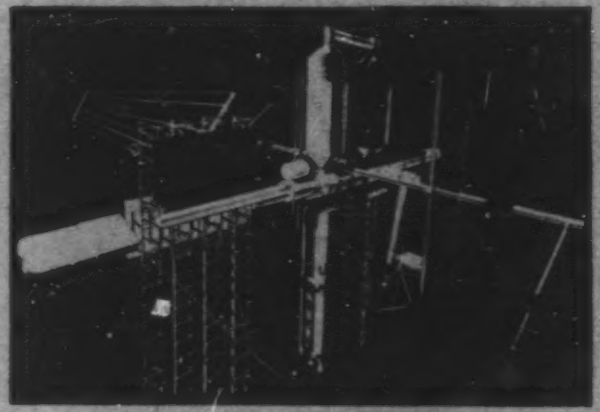
DISTRIBUTED/ADAPTIVE CONTROLS TECHNOLOGY

CONTROLS AND HUMAN FACTORS

STRUCTURAL VIBRATION



LABORATORY DEMONSTRATION OF DAMPING — 1982, 1983



SPACE STRUCTURE WITH DISTRIBUTED/ADAPTIVE CONTROL

MULTIPARAMETER ADAPTIVE CONTROL CONCEPTS 1984

NASA

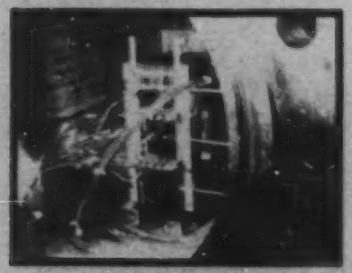
Figure 9

OAST

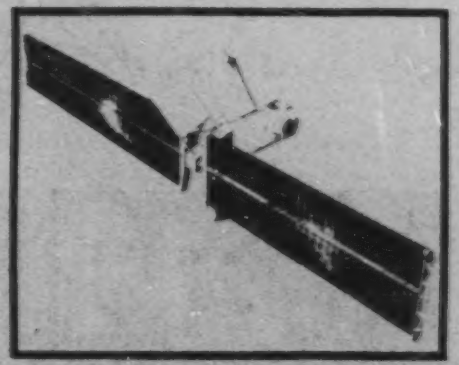
TECHNOLOGY FOR HIGH CAPACITY ELECTRIC POWER SYSTEMS

SPACE ENERGY CONVERSION

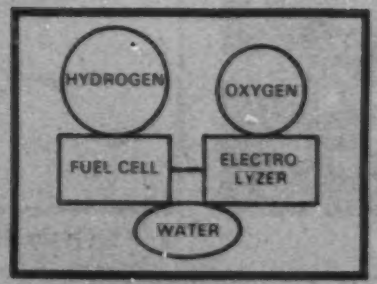
NICKEL-HYDROGEN BIPOLAR BATTERY



- POWER GENERATION
- STORAGE
- MANAGEMENT



1983 FEASIBILITY DEMONSTRATION



FUEL CELL/ELECTROLYZER

MULTIHUNDRED KILOWATT SPACE POWER SYSTEM

EVALUATE BREADBOARD 1984

NASA

Figure 10

OAST

TECHNOLOGY BASE IN COMPUTER SCIENCE

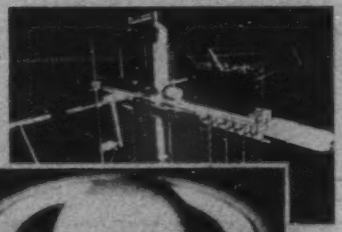
COMPUTER SCIENCE AND ELECTRONICS

NEW RESEARCH PROGRAM DEFINED, 1982

- RELIABLE COMPUTING
- CONCURRENT PROCESSING
- INFORMATION MANAGEMENT

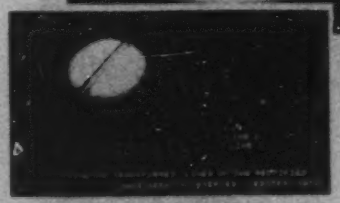
LSI/VLSI FAULT TOLERANT CIRCUIT ARCHITECTURE 1984

- FAULT TOLERANT CONTROL



- IMAGE PROCESSING

- INTERACTIVE DISPLAY



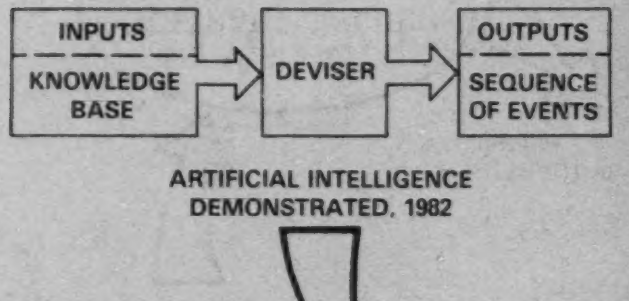
NASA

Figure 11

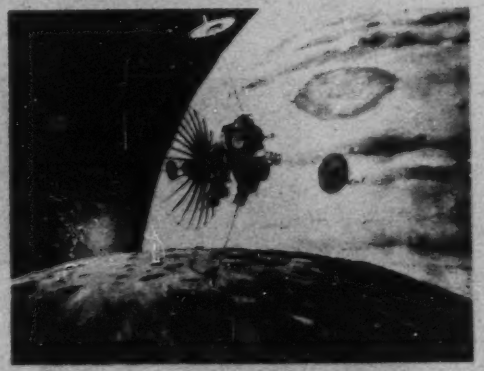
OAST

TECHNOLOGY BASE FOR AUTONOMOUS SYSTEMS

COMPUTER SCIENCE AND ELECTRONICS



ARTIFICIAL INTELLIGENCE DEMONSTRATED, 1982



DEMONSTRATE AUTOMATED DETECTION AND DIAGNOSIS 1984

AUTONOMOUS OPERATION

- IMPROVED PRODUCTIVITY
- EXPANDED SPACECRAFT FUNCTION

NASA

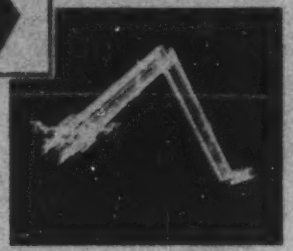
Figure 12

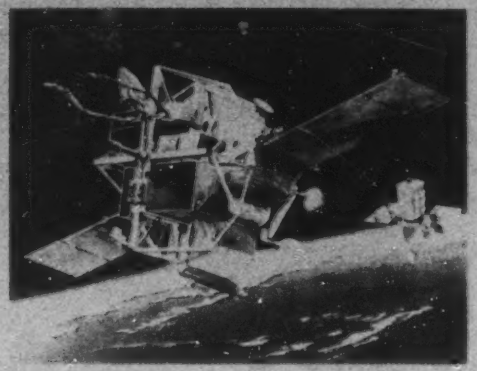
OAST NASA HQ RSB3 797 (3) 1-14-83

TECHNOLOGY BASE TO EXTEND HUMAN CAPABILITY IN SPACE

CONTROLS AND HUMAN FACTORS

- SATELLITE SERVICING
- ORBITAL ASSEMBLY





LABORATORY SIMULATION CAPABILITY 1982, 1983

ORBITAL TELEOPERATOR CAPABILITY

HIGH FIDELITY TELEOPERATOR SIMULATION CAPABILITY 1984

NASA

Figure 13

OAST

NASA HQ RS705 (3)
1-14-83

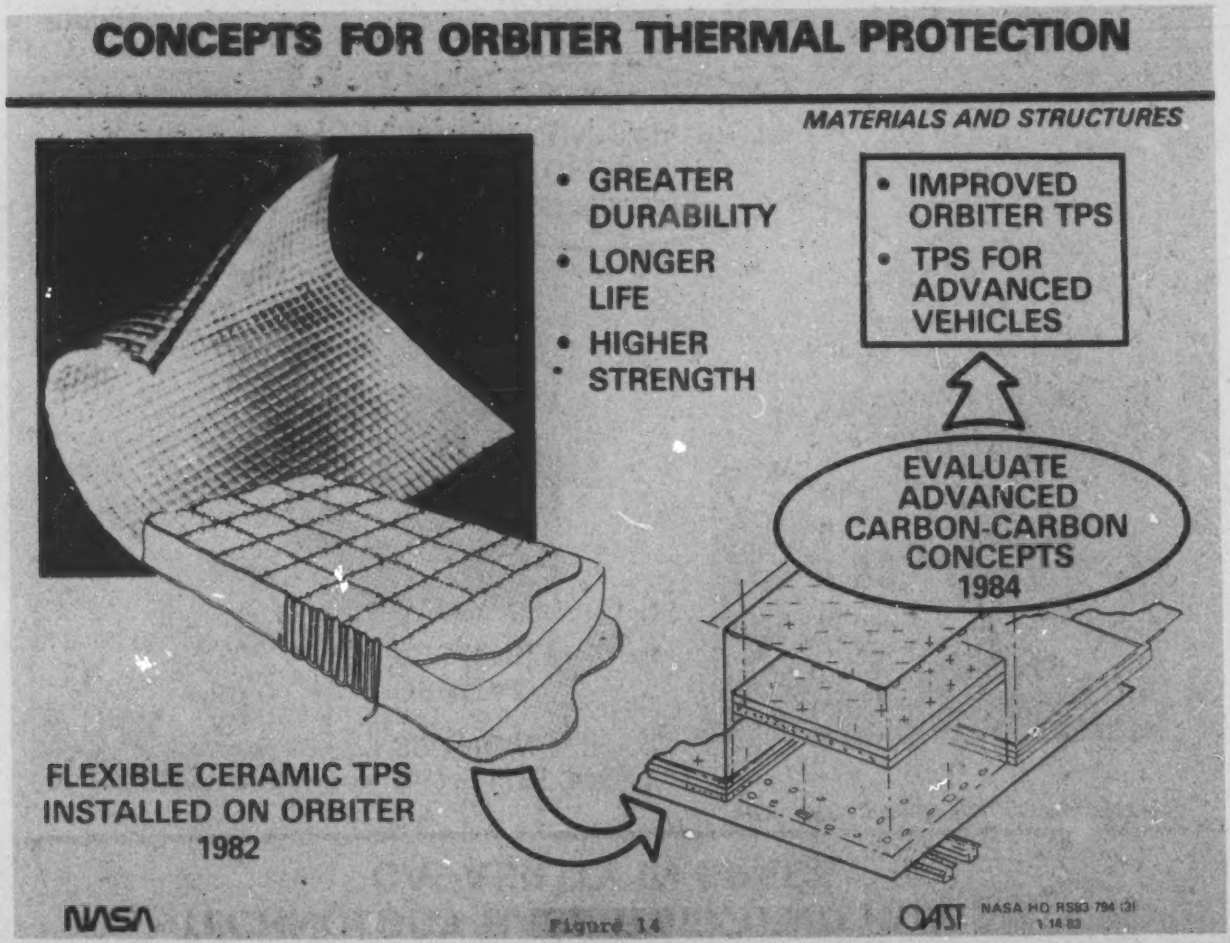

CONCEPTS FOR ORBITER THERMAL PROTECTION
MATERIALS AND STRUCTURES
• GREATER DURABILITY
• LONGER LIFE
• HIGHER STRENGTH
• IMPROVED ORBITER TPS
• TPS FOR ADVANCED VEHICLES
EVALUATE ADVANCED CARBON-CARBON CONCEPTS 1984
FLEXIBLE CERAMIC TPS INSTALLED ON ORBITER 1982
NASA
OAST
NASA HQ RS93 794 (3)
1-14-83

Figure 14

Responses to Written Questions resulting from the February 10, 1983, hearing, at which Dr. Kerrebrock testified.

QUESTION R-1:

The FY 1984 budget estimate for the Space Research and Technology program is $138 million.

a. Have you put increased emphasis on military-related technology?

b. What ongoing activities have the greatest potential for commercial applications?

c. Excluding the $4.6 million for standards and practices, how do you plan to allocate the money among National Security, Civil Government, and Commercial work?

ANSWER R-1:

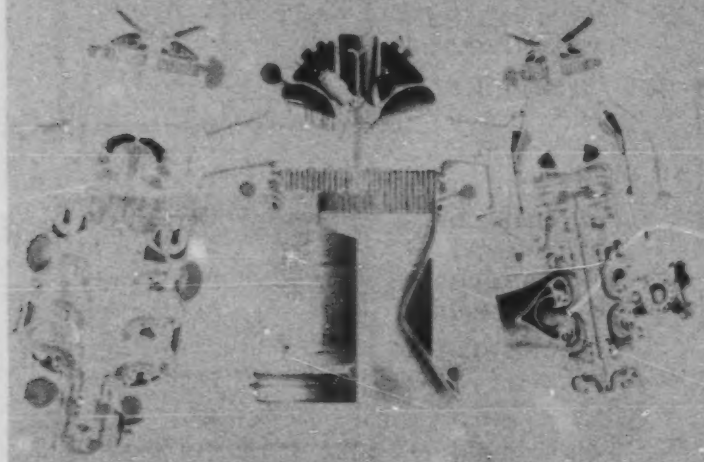
a. The NASA Space R&T program is a broad-based, discipline-oriented, fundamental research effort that is primarily opportunity driven and is typically years ahead of identified application requirements. The fundamental character of the program, in most cases, leads to advances in technology that are commonly applicable to both civil and military applications.

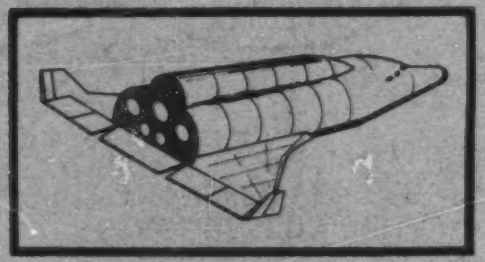
b. When OAST technology advances mature to a state of potential application, further developments are carried out by the appropriate user. Within NASA, technologies attractive to space science and civil space application requirements are applied by the NASA Office of Space Science and Applications; and those technologies of particular interest to space flight are further developed by the NASA Office of Space Flight. Military-relevant technology is carried to application by the Department of Defense. Ongoing activities holding the greatest potential for commercial interests (in remote sensing and communications, just as two examples) include advanced communications, sensors, computer science, propulsion and space power, and materials.

c. In Table A we have estimated the portion of the budget that could have application potential to military, commercial and civil government activities. As is apparent, the sum of these categories greatly exceeds the budget because of the program's synergistic value.

TECHNOLOGY FOR LONGER-LIFE, REUSABLE ENGINES

PROPULSION





HIGH PERFORMANCE, LONG-LIFE ENGINES

ADDRESSED CRITICAL TECHNOLOGIES

- BEARING LIFE
- ROTORDYNAMIC ANALYSIS
- HOT GAS DYNAMIC LOADS
- DIAGNOSTIC INSTRUMENTATION

MODELING CAPABILITY FOR HOT GAS ENVIRONMENT

NASA

Figure 15

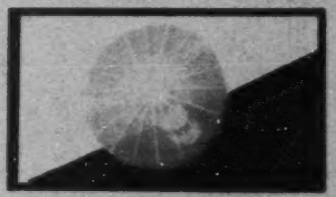
OAST NASA HQ RS83 784 (3) 1-14-83

TECHNOLOGY FOR OTV PROPULSION AND TANKAGE

SPACE TRANSPORTATION SYSTEMS

ADVANCED OTV ENGINE

- REUSABLE
- SPACE MAINTAINABLE
- THROTTLEABLE
- HIGH-PERFORMANCE

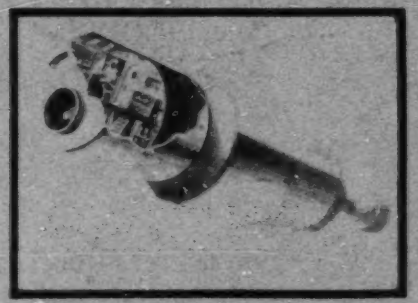


AEROASSIST

- BRAKE MATERIAL
- ADAPTIVE CONTROLS
- ATMOSPHERIC UNCERTAINTY

SPACE REFUELING

- MANAGEMENT OF CRYO FLUIDS
- LOW LOSS TANKAGE



SPACE-BASED ORBITAL TRANSFER VEHICLE

SYSTEM CONCEPT 1984

NASA

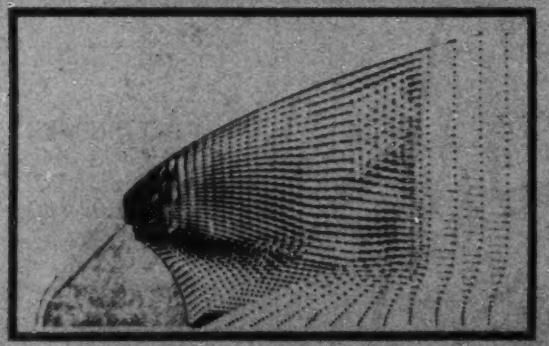
Figure 16

OAST

COMPUTATIONAL FLUID DYNAMICS TECHNIQUES

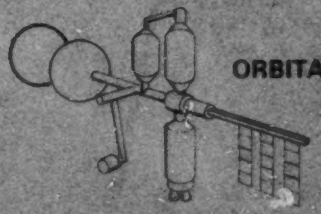
FLUID AND THERMAL PHYSICS

ADAPTIVE GRID CODES FOR COMPLETE FLOWFIELDS 1982/1983

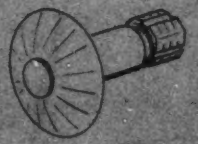


COMPUTED FLOW VECTORS FOR GALILEO PROBE

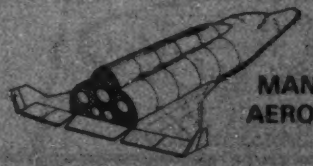
RAREFIED-TO-CONTINUUM FLOW REGIMES



ORBITAL DRAG



LIFT
DRAG
HEATING



MANEUVERING AERODYNAMICS

DEVELOP 3-D FLOWFIELD PREDICTION TECHNIQUES 1984

NASA

Figure 17

OAST

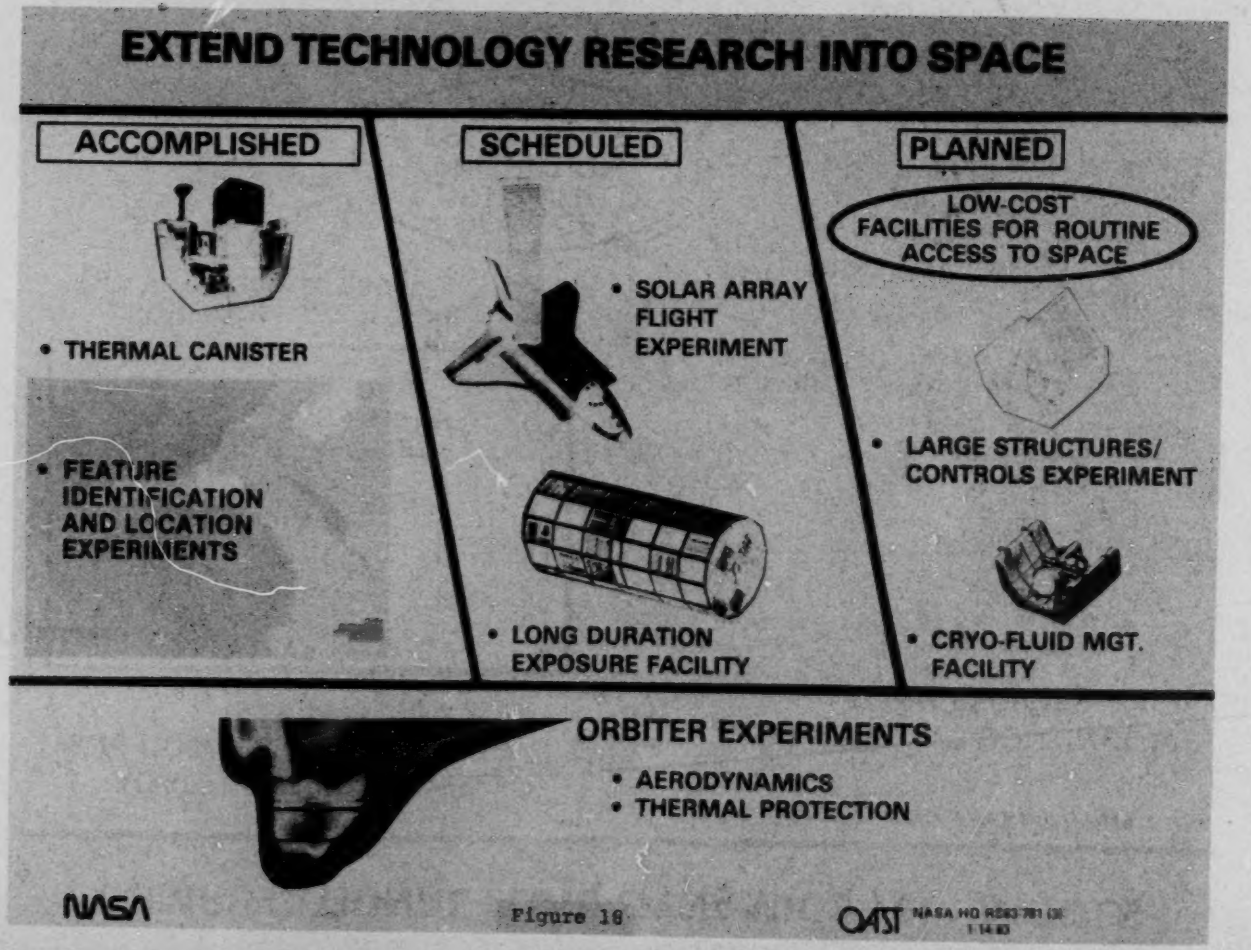

EXTEND TECHNOLOGY RESEARCH INTO SPACE
ACCOMPLISHED
• THERMAL CANISTER
• FEATURE IDENTIFICATION AND LOCATION EXPERIMENTS
SCHEDULED
• SOLAR ARRAY FLIGHT EXPERIMENT
• LONG DURATION EXPOSURE FACILITY
PLANNED
LOW-COST FACILITIES FOR ROUTINE ACCESS TO SPACE
• LARGE STRUCTURES/ CONTROLS EXPERIMENT
• CRYO-FLUID MGT. FACILITY
ORBITER EXPERIMENTS
• AERODYNAMICS
• THERMAL PROTECTION
NASA
OAST

Figure 18

INTERACTIVE PLANNING FOR NATIONAL SPACE R&T PROGRAM

NASA

OAST NASA HQ RS82-539(3) 1-25-82

Figure 19

TABLE A

	($,M)	APPLICABILITY OF PROGRAM		
	FY 1984 R&D BUDGET	NATIONAL SECURITY	CIVIL GOVERNMENT	COMMERCIAL
SPACE RESEARCH AND TECHNOLOGY	133.4	114.5	130.8	97.7
Research and Technology Base	126.2	107.6	123.6	93.2
Fluid & Thermal Physics	8.8	6.2	6.2	4.4
Materials & Structures	15.7	13.4	15.7	15.7
Computer Science & Electronics	16.3	11.4	16.3	9.8
Space Energy Conversion	18.0	18.0	18.0	18.0
Multidisciplinary Research	1.0	0.5	1.0	0.5
Controls & Human Factors	7.6	7.6	7.6	6.1
Space Data & Communications	19.3	16.4	19.3	15.4
Chemical Propulsion	15.7	14.9	15.7	13.4
Spacecraft Systems	3.7	0.7	3.7	3.3
Transportation Systems	8.0	6.4	8.0	2.4
Platform Systems	12.1	12.1	12.1	4.2
Systems Technology Programs	7.2	6.9	7.2	4.5
Spacecraft Systems Technology	7.2	6.9	7.2	4.5
Space Flight Experiments	5.5	5.5	5.5	3.3
Long Duration Exposure Facility	0.7	0.4	0.7	0.2
Ion Auxiliary Propulsion System	1.0	1.0	1.0	1.0

QUESTION R-2:

The FY 1983 NASA operating plan and the FY 1984 budget estimate for the Space Research and Technology Base show a shift in emphasis toward controls and human factors, and platform systems research and technology. Would you please explain the reasons behind these moves?

ANSWER R-2:

The shifts in emphases are part of the continual process of maintaining an R&T Base that is current and relevant to potential future agency missions and national priorities. In this regard, there is a potential trend towards large space platform structures applicable to both unmanned and potential manned systems, such as space station. Funding for the space controls research and technology program was increased because it was recognized to be a high payoff area in which technology advances could make a dramatic impact on capability for control of Earth-orbiting structures such as large antennas, planetary spacecraft, and platform systems. An R&T Base program in human factors was initiated to provide for research directed at extending human capabilities in space. This program, expanded in FY 1984, will provide a generic technology base for improved man-machine interfaces in future spacecraft systems. The platform tasks include technology augmentations supporting space operations and development of systems simulation tools.

QUESTION R-3:

In the area of fluid and thermal physics, please explain the apparent emphasis on aerothermodynamics technology. What work is being done in interplanetary regimes to maintain a balanced program?

ANSWER R-3:

The present emphasis in aerothermodynamics is on very basic chemical kinetics and convective and radiative heat transfer as encountered in aeroassisted orbital transfer vehicle (OTV) operation and in extended maneuvering flight on entry from lower orbit space flight. The technology developed will provide the basic knowledge both for penetration of the earth's atmosphere and also for planetary entry, where unknown atmospheric conditions will be encountered.

In addition to aerothermodynamics, the Space R&T program provides a broad generic base of R&T directly applicable to interplanetary regimes. This includes, for example, thermal protection (heat shields), lubricants, magneto-plasmadynamic thruster, electric propulsion, high performance solar arrays, thermal-to-electric conversion, electronics, data systems, communication systems, automation, artificial intelligence, and autonomous

control for both on-board and ground functions.

QUESTION R-4:

In view of the fact that the Shuttle has entered the operational phase and there are no firm plans for a fifth orbiter, it does not seem appropriate to spend materials and structures R&T money in FY 1984 on Shuttle-related work, unless it is for Shuttle improvements. Please comment.

ANSWER R-4:

The thrust of the materials and structures program is to develop advanced materials and concepts with greater life, durability, and higher performance. As the research progresses, some concepts and materials have shown themselves to be immediately applicable to the current orbiter system, such as the new blanket insulation material (AFRSI) for improved thermal protection system (TPS) durability. Although AFRSI was developed for lower cost and greater damage tolerance, it does offer a modest weight saving over existing tile. The Discovery will have approximately 2800 square feet of AFRSI. This will result in a weight saving of approximately 300 pounds over the densified tile it replaces. It is anticipated, however, that future space transportation systems (OTV, on-demand vehicles, etc.) will require further advances in TPS. The advanced carbon-carbon research now underway at Langley Research Center should provide for enhanced options for these future transportation systems.

QUESTION R-5:

The computer science research program has recently been initiated. As this program appears fundamental to future computer science and electronics activities, what percentage of the $16.3 million FY 1984 budget is estimated for computer science research? Does NASA have the professional staff to meet the computer science research goals?

ANSWER R-5:

Approximately 20% of the $16.3 million FY 1984 budget is estimated for computer science research.

Within the Agency, we have a few key individuals who are recognized nationally as experts in the computer science area. One of our objectives is to increase the number of professionals in NASA to meet the long range requirements of the Agency in this area. To accomplish this objective, we are making use of institutes, in-house experts, and direct grants to universities.

19-605 O--83----17

QUESTION R-6:

The space energy conversion program shows a reduction from FY 1983 budget estimates in part because of the termination in laser propulsion.

a. Do you intend to pursue the long-term laser effort in FY 1983 that the committee requested?
b. Please explain your plans for laser research in FY 1984 and its potential applications.

ANSWER R-6:

a. Laser propulsion research was phased out in order to pursue other higher priority laser efforts. However, NASA is continuing a long-term Research and Technology Base program in laser research funded at about $0.8 million in FY 1983. This program primarily emphasizes solar pumped laser research.
b. The FY 1984 Space Energy Conversion program continues its FY 1983 thrusts in solar and blackbody pumped lasers and laser-to-electric energy conversion. Basic advances in laser technology resulting from this research program may lead to applications involving space power transmission such as power relays and central power stations.

In addition, laser research is conducted under the Computer Science and Electronics and Space Data and Communications R&T Base programs. The primary thrusts of these efforts are in low power, highly stable and tunable laser sources for active and passive remote sensing, such as LIDAR (Laser Imaging, Detection and Ranging), high-speed data links, and communications links. The lasers include ultra-violet/visible lasers such as dye and excimer lasers, space-qualified carbon dioxide lasers, and solid state and semiconductor lasers.

QUESTION R-7:

Please explain the Fund for Independent Research and its relationship to the multidisciplinary research. What percentage of the $1 million for multidisciplinary research will be performed by universities and what does this represent as a reduction in funds for the universities?

ANSWER R-7:

The Fund for Independent Research (FIR) program sponsors novel, long-range, high risk basic research through unsolicited proposals from the universities. In the past, the FIR was budgeted as part of the multidisciplinary R&T program. The FIR program objectives are now accomplished in conjunction with the disciplinary R&T program.

The $1 million budgeted for the multidisciplinary program in FY 1984 will support the definition and development of experiments in physics and chemistry that employ the unique characteristics of the space environment and enhance the fundamental knowledge of material properties and processes. These efforts are accomplished through research grants to universities.

Overall the university grant portion of the Space R&T budget has increased slightly in FY 1984 relative to FY 1983 and prior years.

QUESTION R-8:

Please tell us what you are developing in your space data and communications program that you expect to flight test on the Advanced Communications Technology Satellite (ACTS) project. How much do you plan to spend on ACTS related research in FY 1984?

ANSWER R-8:

Most of the technologies we have developed which are applicable to the ACTS project, including 20 GHz traveling wave tubes and ferrite switches, have advanced to the point that they have been transitioned to the Office of Space Science and Applications program. They are expected to be included in the core of the ACTS system. One candidate that may be included in the overall ACTS project is a tunneladder traveling wave tube for low cost ground stations, since ground station development can lag the development of the spacecraft.

Since the ACTS project is in its formative stages of definition, the technologies embodied therein must be available now or in the very near future. Our program is directed at developing high risk advanced technologies for future applications and therefore the research to be conducted in FY 1984 is aimed at developing advanced technology for the long term. These high payoff technologies include the development of microwave monolithic integrated circuits for low-cost space feed systems and the design and test of advanced antennae configurations.

QUESTION R-9:

In the Chemical Propulsion area, there is mention of increased emphasis on orbital transfer propulsion work in both FY 1983 and FY 1984. Is this trend likely to continue and is the thrust of this research toward the development of a reusable orbital transfer vehicle?

ANSWER R-9:

The emphasis on orbital transfer propulsion work in FY 1983 and 1984 continues the program initiated in FY 1981

and 1982, and is scoped to support a possible mid-1990's orbital transfer vehicle (OTV). The program is focused on developing concepts for a higher performance engine whose thrust level can be tailored to specific mission requirements. The plan is to carry these concepts from studies through component hardware and, eventually, to engine system tests. Work will be initiated in FY 1984 in critical technologies for space-basing and orbital maintenance including diagnostic instrumentation for automated assessment of vehicle systems status. Three principal OTV propulsion contracts have been awarded to support the program through the test-bed component systems tests to develop competitive technology options.

QUESTION R-10:

How does the human factors work proposed in the platform systems research program differ from that performed in the controls and human factors area?

ANSWER R-10:

The human factors research performed under the Controls and Human Factors R&T Base disciplinary program provides for fundamental understanding of the capabilities of humans in space and in ground control systems. The human factors work in the Platform Systems R&T Base program would provide for the integration of this fundamental understanding with the other disciplinary elements of a platform system such as structures, materials, thermal and stability control, and electric power.

QUESTION 11:

The space flight experiments program shows a proposed increase in FY 1984 of almost 200 percent over the FY 1983 estimate. Please explain this growth.

ANSWER R-11:

The FY 1984 Space R&T Budget shows a growth in funding for space flight experiments from the current FY 1983 budget of $1.9 million to the FY 1984 level of $5.5 million. The FY 1984 program takes advantage of the opportunity to use the Shuttle/STS as a cost-effective, recoverable, and reusable technology laboratory that extends ground-based experimentation into space. This program is considered to offer highly beneficial returns. This planned growth includes initiating the design of fully reusable, experiment facility platforms for structures and dynamics research and for obtaining data, in-orbit, on cryogenic fluid storage and transfer.

QUESTION R-12:

I understand that NASA and DARPA signed an interim agreement last year to develop space nuclear reactor technology.

a. What is NASA's role in this agreement?
b. What is the status of negotiations to include DOE in a tri-agency agreement?
c. What applications have been identified for a nuclear reactor, and who are the user organizations?
d. When do you anticipate a demonstration flight?
e. What advantages/disadvantages do reactors have over power sources such as solar arrays and radioisotope thermoelectric generators (RTGs)?
f. What is the NASA funding level by fiscal year for nuclear reactor research over the 1982-1985 period, and how does this level compare with those of DARPA and DOE?

ANSWER R-12:

a. By the terms of the interim NASA/DARPA agreement NASA serves on the Interagency Steering Committee, provides the Deputy Program Director, acts as agent for DARPA funds and manages the project through the Jet Propulsion Laboratory.

b. The negotiations with DOE have been concluded and a tri-agency agreement was signed on February 11, 1983, to replace the interim NASA/DARPA agreement.

c. Potential civil applications include outer planet exploration, lunar and planetary bases, advanced broadcast satellite systems, central power distribution systems and manned platforms. The Department of Defense is exploring a variety of applications including surveillance and communications systems.

d. The program is in the critical technology and mission definition stage. A decision to proceed with the development of a ground engineering system is expected by the end of 1985. The desirability or necessity for flight demonstration has not yet been determined.

e. Nuclear reactor power systems are expected to provide much higher power levels than are practical with radioisotopes. In addition, such systems are inherently both independent of sunlight and resistant to certain kinds of radiation such as encountered in the Van Allen Belt. They also have the potential advantage of higher energy density than solar power systems. A potential disadvantage is the operational safety constraints associated with the nuclear subsystem.

f. The funding levels, as agreed to in the tri-agency MOA, are as follows:

CURRENT YEAR ($Million)

	FY 82		FY 83		FY 84		FY 85	
DARPA	2.0		4.0		5.0		8.0	
DOE	1.3		2.5		4.1		4.1	
NASA	2.4	(+5DMY*)	2.9	(+10DMY)	3.9	(+10DMY)	3.9	(+10DMY)
TOTAL	5.7		9.4		13.0		16.0	

* Direct man years

Mr. VOLKMER. Thank you, Dr. Kerrebrock.

Mr. Lowery.

Mr. LOWERY. $138 million excluding $4.6 for standards and practices. How are you going to divvy up the remaining $133.4 amongst military, commercial, and civilian type activities?

Dr. KERREBROCK. We consider it our responsibility to run a base R&T program which generates technological opportunities which can be exploited then by any of the mission-oriented organizations as they see appropriate. In that sense, the things that we do are not driven by the requirements of those agencies but rather have the character of exploiting technological opportunity and generating ideas and concepts.

It would be possible for us to identify the potential applications of the various activities in our program to each of the three sectors that you mentioned. If we do that, we will find that the sum total of the activities will be a significant multiple of the program.

Mr. LOWERY. You are telling me you are not driven primarily by applications for the future, but by expanding upon past technologies?

Dr. KERREBROCK. No, sir, we are intent upon generating new technologies.

Mr. LOWERY. I understand, but expansion from where we have been as opposed to being driven for a particular well defined need for the future.

Dr. KERREBROCK. It is not expansion from where we have been, but rather generating new ideas and developing them to the point where their applicability to some requirement can be assessed.

Mr. LOWERY. You say it would be about equal across the board then, DOD, as well as civil, commercial applications?

Dr. KERREBROCK. I would say that it would be equally applicable to all three which means that it is three times as good a program as if it was just for one. You understand my point

Mr. LOWERY. Sure. That is the way Government logic works consistently in the budget.

Dr. KERREBROCK. For example, many of the base technologies which are required for construction of a military surveillance satellite are not different from those required for a commercial communications satellite. So anything we do to advance the propulsion, the structures or the power systems for a satellite is applicable to both.

Mr. LOWERY. How do you differ from the Air Force Center?

Dr. KERREBROCK. The Air Force Space Technology Center has just been formed.

Mr. LOWERY. How much money is committed to that?

Dr. KERREBROCK. Very little at this time, I believe $5 to $10 million. At the present time, it is a very small program; but, obviously the Air Force intends to grow. We are closely coordinating with them to insure that as they construct a program it will not be duplicative of ours but rather supportive.

Mr. LOWERY. Thank you, Mr. Chairman.

Mr. VOLKMER. Mr. Bateman.

Mr. BATEMAN. Thank you, Mr. Chairman.

The questions that I am most immediately concerned with, Dr. Kerrebrock, are questions that more appropriately come under the

jurisdiction of the Transportation, Aviation and Materials Subcommittee to which you testified were before yesterday and which I was unable to sit in on. I would like to follow up on some questions in the area of the subsonic research activities and the non-funding in the fiscal year 1984 budget of certain of those programs that I understand have large potential for fruitful results if extended to completion.

So I would like to reserve the right to present some questions on that.

Dr. KERREBROCK. Yes, sir.

Mr. VOLKMER. You want to make those questions now or submit them in writing?

Mr. BATEMAN. I think it would probably be better to do it in writing as it falls under the jurisdiction of another subcommittee.

Dr. KERREBROCK. We would be happy to respond.

Mr. VOLKMER. Those are on aeronautics.

Mr. BATEMAN. Yes.

Mr. VOLKMER. Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman.

Dr. Kerrebrock, it is good to see you. I haven't been here for the testimony, but in reviewing the statement I see you deal with the whole area of computer science and electronics and I would to ask: The computer science research program has recently been initiated. As this program appears fundamental to the future computer science and electronics activities, what percentage of the $16.3 million fiscal year 1984 budget is estimated for computer science research? Does NASA have the professional staff to meet the computer science research goals?

Dr. KERREBROCK. Let me take the last question first. We have a high degree of competence in computer science and its applications in NASA. We recognize though that in such a rapidly growing field we shouldn't stand pat; therefore, we are increasing that competence as rapidly as possible.

Mr. MINETA. The chip that was up here, is that an example of work that comes out of OAST?

Dr. KERREBROCK. Yes, sir.

Mr. MINETA. So that is in conjunction with JPL?

Dr. KERREBROCK. That is done by Goddard.

Mr. MINETA. Goddard?

Dr. KERREBROCK. Yes.

Mr. MINETA. So the work on the LSI, and VLSI circuits is through your shop.

Dr. KERREBROCK. The work is done at JPL; but, that is our shop.

Mr. MINETA. How much by itself is that chip that we saw up here?

Dr. KERREBROCK. Do you mean how many chips like that are there in the MPP? If that is the question, it is hundreds.

Dr. HARRIS. There are eight processors on that one chip with no random access memory. It is in a 2 by 4 multiprocessor array configuration.

Dr. KERREBROCK. There are more than 2,000 chips like that in the MPP. The answer to your first question, we would estimate that about 20 percent of the $16.3 million budget is directly addressing the computer science research.

Mr. MINETA. That is for circuit design.

Dr. KERREBROCK. No, it is directed mostly at things other than circuit design, such as the development of highly reliable software, concurrent processing techniques, and information transfer systems.

Mr. MINETA. You are not on the hard side, you are more on the soft side.

Dr. KERREBROCK. That is right. It is very important that we are not competing with the large electronics companies or that very large community which is intent on building better integrated circuits and solid state devices. We are attempting to concentrate on those aspects of computer science more specifically critical to the aerospace area, and where the other community is not paying specific attention. Concurrent processing, for example, is an aspect because of its importance to image processing, numerical aerodynamic simulation, and to fault-tolerant, highly reliable computational systems. We feel we should pay a great deal of attention to it.

Mr. MINETA. Turning to the space energy conversion, the space energy conversion programs show a reduction from 1983 budget estimates in part because of the termination in laser propulsion. I am wondering do you intend to pursue the long-term laser effort in fiscal 1983 that the committee requested?

Dr. KERREBROCK. We intend to continue with a long-term effort in laser research. The emphasis of this effort is on lasers for communications, data links, and remote sensing rather than for directed energy applications. At the present time there is considerable emphasis on solar-pumped lasers which is work being carried on at the Langley Research Center.

Mr. MINETA. And is that what your laser research program in fiscal year 1984 is going to be?

Dr. KERREBROCK. Yes, sir.

Mr. MINETA. And given that emphasis on the solar pump research, where do you see its potential application?

Dr. KERREBROCK. I don't want to imply that we are working only on solar-pumped lasers. The emphasis is on the development of advanced laser concepts for use in space. In my mind, the principal application of these is for communications, data links, remote sensing and possibly, in the far term, for space power transportation.

Mr. MINETA. How much is being taken away from what this committee had requested in terms of long-term laser research by going toward the solar pump laser?

Dr. KERREBROCK. Nothing, as far as I understand. Our intent is to press the areas of laser research which I mentioned and for which we have allocated funding. If the issue is laser propulsion, it is our judgment that those moneys are better used for other directions that I talked about rather than for concentration on laser propulsion.

Mr. MINETA. I might just touch on space data and communication. Please tell us what you are developing in your space data communication program that you expect to flight test on the ACTS project and how much do you plan to spend on ACTS-related research in fiscal 1984.

Dr. KERREBROCK. The ACTS program is, of course, a flight program in which a 30/20 gigahertz communication system would be put on a satellite and flown at sometime in the future. This pro-

gram is in its formative stages at the present time; so, the technology that will be on it is not really committed yet. However, some of the technological developments that OAST has fostered in the past which are eligible for incorporation on ACTS are a 20 gigahertz traveling wave tube for the down-link, fast-ferrite switches, solid state switches for the power system, and perhaps the tunnel-ladder concept for the traveling wave tube, which incorporates diamond standoffs and is potentially a very strong cost reducer for the traveling wave tubes.

In the future, we intend to press the advanced technology for such systems as we have in the past. One of the things we are concentrating on is microwave monolithic integrated circuits for the 30/20 gigahertz frequency range and advanced configurations. In addition, there are those other technologies that I mentioned, work will be done on structures, power systems, and so forth, which are generic to satellites.

Mr. MINETA. Is that also leading toward miniaturization or is that more for expansion?

Dr. KERREBROCK. As you probably know, some of the most expensive and troublesome components of these communication satellites are the microwave amplifiers.

Mr. MINETA. The TWT is probably the most sensitive and weakest link in that.

Dr. KERREBROCK. That is right and the plumbing system that goes with it—I say plumbing by analogy. Microwave monolithic integrated circuits offer the potential for lighter weight and lower cost microwave circuitry. We are pressing that technology fairly hard.

Mr. MINETA. Thank you very much. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you, Mr. Mineta.

I have a few questions. I would like to continue on just briefly with the line of questioning of Mr. Lowery.

You say that basically the technology development that is coming about can be utilized in the various aspects, whether military, civilian, commercial or what. My question goes further: Those are the areas that you decide you are going to work in, whether planetary, deep probe, suborbital or what. Am I correct in that?

Dr. KERREBROCK. The answer is yes; but, in this sense, OAST has been very aggressive in taking the lead in the establishment of what we call a "space technology systems model." This is a book containing descriptions of potential space applications of future applications. We update this book continually. That space technology model is used as a guide in the prioritization of our base technology program. Furthermore, the Department of Defense, since OAST constructed this model, has put in place its own parallel model. So, the DOD has a space technology model which complements ours and which is used as a guide in establishing their space technology program.

Mr. VOLKMER. All right. Now in developing your model and the research that goes into the technology, how much of that is influenced by, say, what Defense would like to have for defense requirements?

Dr. KERREBROCK. As I said, we do not respond to requirements, as such. Let me say that the Department of Defense does not state

a requirement for any kind of a weapon system until they have established that the technology is available.

If an organization such as ours reacted or responded to stated requirements, we would not develop advanced technology, for the reason that I just gave; the requirement does not reflect the opportunities in technology, it reflects only the technologies that are available. We feel our main responsibility is to put in place those technological opportunities which the Department of Defense and commercial organizations will then recognize and incorporate in their requirements.

Mr. VOLKMER. It is safe to say then, that you are not influenced by military decisions or anything?

Dr. KERREBROCK. That is correct, in the sense that we do not structure our program to meet military requirements.

Mr. VOLKMER. Very well.

In your prepared statement I have noticed that you have some research into the space station platform. Is that correct?

Dr. KERREBROCK. Yes, sir.

Mr. VOLKMER. About how much of your research budget is going into that?

Dr. KERREBROCK. At the present time, we have identified, within our ongoing base R&T program, about $29 million, which is applicable to space station. Let me emphasize that that is work which was ongoing and motivated by the concept before the identification to space station needs was made.

It is not a program that was specifically generated in response to a space station requirement. However, we do make a concerted attempt to insure that to the extent that our program can be focused or directed to be more applicable to a requirement such as a space station, without destroying its base technology content, we do that.

Mr. VOLKMER. It says here, "enhance the capabilities of future space station configurations." You use those terms.

Dr. KERREBROCK. Yes, sir. The configuration for the space station is not set, of course.

Mr. VOLKMER. I agree. It is something. Right now you couldn't find it or draw a picture of it.

Dr. KERREBROCK. It is a permanent presence in space.

Mr. VOLKMER. Right. But does this mean that you do have some idea of a configuration?

Dr. KERREBROCK. We have an idea, as a result of very extensive studies that we have been conducting in-house, of the potential technological needs and applicability to the space station, that there are certain elements of critical importance. One of these is the information system. It is clear a space station has to have a more powerful, more efficient system for handling information than we have in place in space now. If it is to be as useful as possible, it has to have a better power system. Spacecraft now have low voltage DC power systems, which involves too much copper wire, to put it simply. We have to evolve a higher voltage, more efficient power system for a space station. Another critical element is the life support system. Presently, the life support system of the shuttle is essentially a through-flow system. One uses up consumables and we need to put in place the capability for recycling water, for

example. There are many other opportunities for economizing on the material that has to be taken into orbit.

Mr. VOLKMER. When you talk about configuration you talk about basic components that would be necessary to enhance our present knowledge in order to develop a space permanency.

Dr. KERREBROCK. Yes, we are talking about advancing the basic technology. So, when we are ready to design a space station, it can be done with the best possible technology.

Mr. VOLKMER. Now in view of the fact that the shuttle has entered the operational phase, and with no firm plans for a fifth orbiter, I would like to know if you feel it is appropriate or not appropriate to spend materials and structures R&T money in fiscal 1984 on shuttle related work.

Dr. KERREBROCK. Yes, sir, it is extremely important to continue improving materials and the basic understanding of the limiting factors in vehicles such as the shuttle particularly in order to continually upgrade its performance and reduce its operating costs.

Mr. VOLKMER. Now is this looking forward to say reengineering parts of the existing shuttle fleet or is that looking forward to, maybe, 10, 15 years down the line for a new type of shuttle?

Dr. KERREBROCK. It is both, but we believe the shuttle will be with us in its principal configuration for a long time. Therefore, it is very important to continually advance our understanding of the factors that limit its performance. For example, the life of the main engine is limited by the materials and their behavior in the very severe thermal and stress environment to which they are subjected. If by improving the understanding of the behavior of those materials, we can extend the life of the main engines by even a few percent, it will result in enormous economic savings as well as the possibility for improved performance of the vehicle, in terms of increased lifting capability.

So, we feel it is important to work at more basic understandings of the materials and fluid mechanics of the main engines.

Mr. VOLKMER. What you tell me then, and correct me if I am wrong, is that the existing engines would have to be reworked, taken back.

Dr. KERREBROCK. Not necessarily. One operates a device like that very cautiously, as it has a service life. If you can develop enough confidence to extend your estimate of the service life, then you can run the engine longer before overhauling or replacing it.

Mr. VOLKMER. What I am getting at is if you do find appropriate changes are to be made, then the engine that is now sitting down in Florida on the Challenger, will have to be taken back and overhauled and make those changes, would they not?

Dr. KERREBROCK. Not necessarily. Those engines are not static things. The turbo pumps, for example, are changed out fairly often. If you can install a turbopump with a longer life, then you have made a big gain.

Mr. VOLKMER. I have no further questions. Does anyone else?

Mr. MINETA. Mr. Chairman, if I might, just going over your chart on funding distribution I notice it is very well laid out in terms of the various kinds of things that are done at the various centers.

I notice that at Marshall you have structures and materials and at Langley you have materials and structures. I was just wondering

what difference, not so much the order in which words are, but the differences in terms of the kind of materials or structures that are being dealt with at Langley as compared to Marshall.

Dr. KERREBROCK. In that particular case the materials and structures worked at Marshall are focused on the propulsion system. They have the responsibility for the main engines. We work closely with them in advancing the understanding of the materials behavior. Lewis is also involved in that very strongly. Langley has been more interested in the structural materials for air frames and space frames, composite materials.

Mr. MINETA. If you are talking about the main engine.

Dr. KERREBROCK. That would be Marshall and Lewis.

Mr. MINETA. If you are talking about the structure of the vehicle itself you are talking about Langley.

Dr. KERREBROCK. Yes; for the thermal protection system, it is Ames that has taken the lead, in the tiles and in this material that I showed you.

Mr. MINETA. Let me also ask about space energy conversion. I understand that NASA and DARPA signed an interim agreement last year to develop space nuclear reactor technology. I am wondering what is NASA's role in that agreement.

Dr. KERREBROCK. We share with DARPA the responsiblity as systems and user participants in the program. The responsibility of DOE is essentially the nuclear components of the system.

That is a basic technology program which is intended to advance all of the critical technologies of the space nuclear power systems to the point where we can make a decision in the future to go ahead with a ground demonstration experiment. Perhaps, after that decision is made, there may be a commitment to an operational system. But, at the present time, we are focused on generating the technology base for a high performance spaced-based nuclear power system.

Mr. MINETA. Are you saying there is going to be a tri-agency agreement?

Dr. KERREBROCK. Yes, sir.

Mr. MINETA. Including Department of Energy?

Dr. KERREBROCK. That is our hope.

Mr. MINETA. What is the status then of those negotiations?

Dr. KERREBROCK. We are still negotiating; but, we have a pretty good basis for signing a tri-agency memorandum of understanding in the near future.

Mr. MINETA. When do you anticipate signing that?

Dr. KERREBROCK. As soon as possible, sir.

Mr. MINETA. What applications have been identified for a nuclear reactor and who are the user organizations?

Dr. KERREBROCK. There are no—let me emphasize, there are no requirements at the present time. But potential applications are several. The Department of Defense has an application for a high powered radar, potentially. We have identified applications for a nuclear electric propulsion system for a vehicle that would rendezvous with the rings of Saturn to provide for extensive exploration of the rings. By going into a trajectory which is essentially parallel to the rings but out of their plane, one can observe the rings of Saturn from a fairly close distance.

Mr. MINETA. In that instance the user organization would be?
Dr. KERREBROCK. NASA.
Mr. MINETA. NASA.
Dr. KERREBROCK. Yes.
Mr. MINETA. Any other user organizations?
Dr. KERREBROCK. I think at the present time it would be NASA or DOD.
Mr. MINETA. DOD on the high powered radar.
Dr. KERREBROCK. Yes, sir, but let me emphasize that that is not a stated requirement, it is just a potential application.
Mr. MINETA. And when do you anticipate a demonstration flight?
Dr. KERREBROCK. We have no plans for a demonstration flight so I would not anticipate it. The next step after the base technology program would probably be a ground demonstration experiment or a ground system experiment.
Mr. MINETA. All on the ground?
Dr. KERREBROCK. Yes.
Mr. MINETA. What advantage or disadvantage do reactors have over power sources such as solar arrays and radioisotope thermoelectric generators?
Dr. KERREBROCK. The reactor, relative to the radioisotope thermoelectric generator, offers higher power level. The power level available with the isotope generators is limited by cost and by the fact that, of course, they run at full power from the time they are assembled, from the time the fuel elements are fabricated.
Mr. MINETA. It has the advantage of power as well as cost?
Dr. KERREBROCK. At high power levels, nuclear reactors are both cheaper and controllable, whereas the radioisotope source is not controllable. You understand it produces a fixed amount of power as soon as the materials are assembled.
Relative to solar cells, the nuclear system offers much higher power-to-mass ratio as well as the ability to operate in a high radiation environment, such as the Van Allen Belt. It also offers a lower drag in low-Earth orbit, which might be very important, for example, for a space station; which has to have very large solar arrays. There is a large consumption of power and propellant to maintain the orbit against the drag of the solar arrays; a nuclear power system could offer a very large reduction in that propellant usage.
It also offers the potential for high performance propulsion and other applications far from the sun. Therefore, it is very important for its extended missions to the outer planets.
Mr. MINETA. And what is NASA's funding level by fiscal year for nuclear reactor research over the 1982 through 1985 period and how does this level of NASA's compare with DARPA and the Department of Energy?
Dr. KERREBROCK. For fiscal year 1983, it is $2.9 million and our share is roughly equal.
Mr. MINETA. Between NASA and DARPA?
Dr. KERREBROCK. Yes; it is about one-third/one-third/one-third between the three agencies.
Mr. MINETA. That is 2.9 for 1983.
Dr. KERREBROCK. It is $2.9 million, then it builds up to about $4 or $5 million a piece over the next 2 or 3 years.

Mr. MINETA. So by fiscal year 1985 you are up to about what?
Dr. KERREBROCK. About $5 million.
Mr. MINETA. Total of $5 million.
Dr. KERREBROCK No, for NASA.
Mr. MINETA. So total of 15.
Dr. KERREBROCK. Total of $15 million? I would like to give you those numbers for the record so that you have them precisely. (See detailed response for question R–12, p. 256.)
Mr. MINETA. Thank you very much.
Mr. VOLKMER. To get back to just one other thing, on the energy activities I understand what you said, but do you envision doing less technology development in energy than you presently are in the future?
Dr. KERREBROCK. I think that will depend on the evolution of the programs of the Department of Energy.
Mr. VOLKMER. But you are basically only going to do things that are related to both energy and NASA. Is that correct?
Dr. KERREBROCK. We intend to continue long-term collaboration with DOE in those areas of technology that we identify as having synergism with our aerospace research. For example, in the work on structural ceramic materials, silicon carbide and silicon nitrate for application in high temperature gas turbine engines, was originated, motivated, and funded by the Department of Energy's program on automative gas turbine engines. We feel those materials may have very, very important applications in aerospace energy conversion systems as well. So, we are very anxious to continue and to share the responsibility for that kind of activity with DOE.
Another class of activities is that in which NASA has managed programs for the Department of Energy, essentially because of our competence for management of high technology programs. We will complete all of our commitments to those programs where they are ongoing.
Mr. VOLKMER. But if the Department of Energy or this committee would decide that we would like to see further research in a certain area; and let's say it is applicable to programs that are now being conducted at Ames, for example, but have very little immediate application to technology to be used by NASA in space, then would you say that is the type that would not be able to be used?
Dr. KERREBROCK. Mr. Chairman, I am stating NASA's policy as I understand it now. We, of course, are anxious to cooperate with you in any way that is reasonable.
Mr. VOLKMER. OK. You are not precluding the other?
Dr. KERREBROCK. I would not.
Mr. VOLKMER. Thank you very much. Anyone else have any further questions?
If not, thank you very much Dr. Kerrebrock. We appreciate your being here.
Mr. VOLKMER. Our final witness today is Robert F. Allnutt, Office of External Affairs.
We have a copy of your prepared statement and that will be made a part of the record. We also have a statement from Mr. Philips and that too will be included in the record.
If you wish, you may review that statement or you may give us a synopsis of it, however you wish.

[A biographical sketch of Mr. Allnutt and Mr. Philips follow:]

ROBERT F. ALLNUTT

Robert F. Allnutt is NASA's Acting Associate Administrator for External Relations, a position he has held three times during his current tour tour at NASA. He became NASA's Deputy General Counsel for Policy Review in late 1981. In that post he conducts reviews of major NASA policies for their legal implications, and performs a number of special assignments for the Administrator and the General Counsel.

He was named to the senior staff position of Associate Deputy Administrator in 1978. In that position, he was responsible to the Administrator for general management of the agency's staff functions, and their coordination with aeronautical and space program activities. He received the NASA Exceptional Service Medal in 1981, and was named a "Meritorious Federal Executive" by President Reagan in the same year.

He came to NASA from the Department of Energy, where he had been Assistant General Counsel for Legislation. He joined the Department's predecessor agency, the Energy Research and Development Administration in 1975, as the Deputy Assistant Administrator (Administration) and managed a wide variety of program areas, including procurement, personnel, labor relations and construction. He received the ERDA Meritorious Service Award for 1976.

A native of Richmond, Va., Allnutt graduated from Virginia Polytechnic Institute with a degree in engineering and received his Juris Doctor (with distinction) and Master of Laws degrees from George Washington University Law School.

In 1957, Allnutt joined the U.S. Patent Office. He subsequently served as a patent attorney with NASA, an attorney for the Communications Satellite Corporation, the NASA Assistant General Counsel (Patents), and as NASA's Assistant Administrator for Legislative Affairs. Allnutt was appointed Associate General Counsel for the Congressionally-established Commission on Government Procurement in 1970. In 1973, he became Staff Director and Counsel of the U.S. Senate Committee on Aeronautical and Space Sciences, the Committee with jurisdiction over Federal aerospace research and development activities and all NASA programs.

He is a member of the bars of the U.S. Supreme Court, the District of Columbia and Virginia and is a member of the Federal and American Bar Associations. He is author and co-author of a number of law review articles and has lectured in law at the American University.

Mr. Allnutt is married to the former Jan Latven of Arlington, Va. They make their home in Bethesda, Md., with their sons David and Thomas.

RONALD J. PHILIPS

From 1978 to December 3, 1981, Mr. Philips has served as Director, Government/Industry Affairs Division, National Aeronautics and Space Administration. On December 3, 1981, he assumed the responsibility for Technology Utilization and now served as Director, Technology Utilization and Industry Affairs. In this capacity he serves as Director of a multidisciplinary staff office which provides daily support and analytical capability to the NASA Administrator and other senior management. He is responsible for monitoring NASA's interactions with all civilian governmental agencies, industry, interest groups and management of the Technology Utilization Program.

From 1971 to 1978, he was Senior Vice President, Public Technology, Inc. One of three founders of a company designed to adapt new technologies to meet the needs of local and state government. He was responsible for all aspects of corporate management, including planning, marketing, and fiscal management.

From 1968 to 1971, he served as Director, Office of Technology Utilization, National Aeronautics and Space Administration. He directed a multidisciplinary, multimillion dollar basic and applied research and engineering program. Planned and directed NASA's entire technology transfer effort in non-space applications of technology developed in the space program. Prior to that position he was Staff Assistant to Mr. James E. Webb, Administrator of NASA.

STATEMENT OF ROBERT F. ALLNUTT, ASSOCIATE ADMINISTRATOR FOR EXTERNAL AFFAIRS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND RONALD J. PHILIPS, DIRECTOR FOR TECHNOLOGY UTILIZATION AND INDUSTRY AFFAIRS, NASA

Mr. ALLNUTT. Thank you, Mr. Chairman.

In the interest of the time of the committee, I think we can be quite brief and submit both statements so that you have all the time you want for questions.

We have appreciated very much and, indeed, have relied on the support of this subcommittee and the full committee over the years for the technology utilization program. We appreciate this chance to appear before you this morning in support of this year's budget.

In order to carry out the kinds of programs that you have been hearing testimony about these past few days, NASA contractors and civil servants have to generate a good deal of new technology. Our job in the technology utilization program is to identify these advances as they are made, to be sure that they are documented and determine where there is commercial potential or appear to have commercial potential, and to try to disseminate information about the innovations as widely as we can.

I thought if I gave you just one example it might help to illustrate what we do and then we could proceed with your questions. In the late 1970's at the Langley Center in Virginia, John Buckley and some of his colleagues were trying to find a way to join plastics in either the vacuum of outer space or in harsh environments and there was no good device to do that. They did find that through an innovation they developed they could come up with a hand held tool that would allow them, in effect, to weld two plastics together regardless of the environment. They called this an induction welder.

The technology utilization officer at Langley documented this advancement, and published a tech-brief which is a one sheet brief description of the invention, which eventually was published in the book I am holding that we put out every year, publishing the tech-briefs that have been chosen as our best ones for the year. That is a very popular book. We had 75,000 subscribers in 1982 and a waiting list of about 15,000 people.

One company that saw the tech-brief is the Inductron Corp., a small company in Grafton, Va. They were interested and felt there was a chance for them to make a commercially viable product. They proceeded to produce this hand-held welder which has been a successful device. They were 1 of about 2,000 companies that inquired about the welder. Inductron was given a patent license under a patent application we had filed. One user of the device now on the market is Dave Brown who runs the Great Falls Canoe and Kayak Repair Co., in Great Falls. Dave is here today. He has the device with him. He finds he can repair plastic canoes or kayaks with the device and if you have time at the end of the hearing, Mr. Chairman, you might want to spend a moment with Dave and let him show you how the device works.

We have published about 15,000 innovations over the last 20 years. Obviously, not every one of them has been a success or has

led to a commercial product or process; but, many of them have. That is the kind of thing we try to accomplish with this program.

We are requesting $4 million to continue the program in fiscal year 1984, and we hope we can have your support.

With that, Mr. Chairman, as you suggested, we will submit our statements for the record and be happy to answer your questions.

[The prepared statements and answers to questions asked of Mr. Allnutt and Mr. Philips follow:]

HOLD FOR RELEASE UNTIL
PRESENTED BY WITNESS
FEBRUARY 10, 1983

Statement of

Robert F. Allnutt
Acting Associate Administrator
for External Relations

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

Thank you for the opportunity to appear before the Subcommittee again this year to present NASA's proposed Technology Utilization Program and supporting budget request for Fiscal Year 1984. This Subcommittee's strong support of the "TU" program over the years has made the program what it is today--a vital mechanism for identifying, developing, and transferring to the non-aerospace industries new technologies emerging from NASA's main line programs.

The past year has been one of reorganization and redirection under the Administrator's realignment of NASA Headquarters' functions. The Technology Utilization Office was combined with Industry and Intergovernmental Affairs under the direction of Mr. Ronald J. Philips, who is accompanying me. We have moved to focus these activities more sharply on pressing problems in U.S. industry, with specific emphasis on developing closer working relations between NASA and our industrial, scientific, technical and business counterparts.

U.S. industry is under real and intensifying international competitive stress. I firmly believe that we in Government, and specifically in NASA, must meet industry halfway if we are to be of help. Along those lines, we are shifting program priorities and methods to better understand industry's problems and opportunities. We along with industry are increasingly looking at our Technology Utilization activities as an extension or adjunct of private industrial research and development. We are going that additional yard by analyzing our technology in conjunction with industry in terms of its applicability to specific industry capabilities, potentials and commercial objectives in the world marketplace. We then look for the best NASA know-how and bring it to bear directly.

For FY 1984, the NASA budget request for Technology Utilization is $4 million. I would like to ask Ron Philips to discuss briefly the budget plan and to speak to some of the highlights of the Program. Then we will be pleased to respond to questions.

Thank you, Mr. Chairman.

Hold for Release Until
Presented by Witness
February 10, 1983

Statement of
Mr. Ronald J. Philips
Director, Technology Utilization and Industry Affairs
Office of External Relations

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the
Subcommittee on Space Science and Applications
Committee on Science and Technology
United States House of Representatives

Mr. Chairman and Members of the Subcommittee:

It is again my pleasure to appear before this Subcommittee to report on our activities in the NASA Technology Utilization Program.

Fiscal year 1984 marks the twenty-first anniversary of the NASA Technology Utilization Program -- a program which has successfully encouraged and stimulated the transfer of aerospace technology to the private sectors of the nation's economy. During this span of time, particularly in recent years, the term "technology transfer" has taken on new dimension and importance, especially as it relates to the urgent priorities of the national economy, through increased industrial productivity, high technology alternatives and in meeting public sector needs in medicine, transportation and public safety and the like.

Last year, NASA maintained an effective program which continued to contribute to the use of advanced technology to improve our national productivity and economic competitiveness. As part of these efforts, we entered into preliminary discussions with State governments which showed special interest in the availability of NASA-spawned technologies to improve or upgrade their respective industrial bases. NASA is working with such organizations to broaden the use of NASA technology, provided that they establish and sponsor the necessary infrastructures to help the flow of these aerospace technologies to Statewide users both in industry as well as State and local government.

In addition, serious thought and planning has focused on aggregating and modernizing NASA technology dissemination mechanisms nationwide. Information searches for industry can be more centralized, permitting reductions in the number of dissemination centers through broader use of new methods such as electronic mail. Heretofore, NASA has sponsored ten (10) dissemination centers located regionally in the U.S. I believe that economies-of-scale can be effected by greater centralization, and yet continue to serve the technical information needs of industry.

As Bob Allnutt indicated, our budget for FY 1984 is $4 million. This budget request is divided between the two sub-program elements: $2.2 million for Technology Dissemination and $1.8 million for Technology Applications. Under Technology Dissemination, we plan to continue new technology evaluation and publication activities, with principal emphasis on NASA Tech Briefs and technical support packages. Under this budget, support for NASA-funded dissemination centers will be significantly reduced as we proceed with our centralization and modernization plans. Program evaluation and support activities will likewise be reduced, but maintained at a minimal level to provide only essential evaluative inputs and support elements to the program as a whole.

The Technology Applications funding level of $1.8 million will allow continuation of one applications team to interact with potential users in the public and private sectors. This funding level will also provide for completion and initiation of high priority applications projects designed to reengineer or apply existing aerospace technologies to defined problems in the public sector.

Let me now review some of the recent specific accomplishments in these program areas during the past year:

TECHNOLOGY DISSEMINATION - $2.2. million

Publications - ($0.9 million)

Last year, NASA announced over 500 additional innovations in its Tech Brief publication. This quarterly journal has been distributed free-of-charge to 75,000 engineers, scientists and businessmen in U.S. industry and thus is considered one of NASA's prime mechanisms for acquainting U.S. industry with technological advancements of high potential utility. Nearly 15,000 such advancements have now been published in NASA Tech Briefs since the program's inception. Interest stimulated by last year's tech brief announcements generated over 80,000 industry requests for additional technical information.

NASA has undertaken an examination of its free distribution policy for tech briefs and has learned that conversion to paid subscription may be possible, provided that the conversion is phased in. Similar experience in the private publishing world indicates that the free-to-paid conversion process is risky and can only be accomplished in a measured fashion over a period of time. Precipitous action in this regard could very well destroy the publication as an effective tool for technology transfer.

Dissemination Center Network - ($0.75 million)

As indicated earlier, NASA plans to centralize technical information retrieval and dissemination service for industry in FY 1984. By using electronic mail, data compaction and other modern techniques of communication, we believe that industrial users of the dissemination center network can be serviced through a more cost-effective method with improved quality of service.

The network as a whole generated in excess of $4.4 million last year. However, two centers, New England Research Applications Center (NERAC), and Computer Software and Management Information Center (COSMIC), accounted for 72% of the total income received from industry for technical information products and computer programs, respectively. Under this proposed budget NASA plans primarily to consolidate its dissemination efforts in FY 1984 in the two major centers which have exhibited the greatest effectiveness in the transfer of NASA technology to industry. NASA will continue, however, to make its technology and data resources available to current dissemination center activities provided that they can acquire funds from respective State governments or other sources to continue their operations. It is believed that several of these centers, specifically those in Florida, North Carolina, Oklahoma and New Mexico have a good chance of continuation with State funds.

NASA also stands ready to assist other States in their quest for technical information resources to support their objectives in economic and industrial development. The States of New Jersey, New York, Michigan, Ohio and Illinois have already expressed interest in availability of aerospace technology in this context. Further, it appears that these States are investigating sponsorship of organizational frameworks to facilitate the transfer and use of technology. NASA encourages these efforts and will undertake to develop where possible the necessary mechanisms to make its technology available for these purposes.

COSMIC has continued to improve and expand its efforts to disseminate NASA-developed computer software for direct application in industry. An all time high of $840,000 in sales and leases of computer programs was realized last year, a clear and strong indication of the value of these products in industry.

Information processing by computer is experiencing explosive growth in the United States and even greater usage of computer software is predicted for the 1980's. Participation in this growth and expansion of NASA's COSMIC program will be continued during fiscal year 1984.

Let me illustrate one example showing how NASA-developed software is paying off in industry:

Researchers of Shell Oil Company used a software package called VISCEL, developed by the Jet Propulsion Laboratory, to analyze structures made of lightweight plastics. Computerized analysis provides vital information to polymer scientists as to how proposed polymeric composite structures will perform prior to actual manufacture. These analyses are employed in the design and manufacture of a myriad of parts for industrial use, including automotive components as well as a host of consumer products ranging from vacuum cleaners, to kitchen appliances to beverage containers.

Industrial Productivity

During this past year NASA, in cooperation with the American Institute of Aeronautics and Astronautics (AIAA), continued its series of industrial seminars which acquaint R&D corporate executives and senior technical managers with on-going research and development activities. This seminar series, initiated in 1980, has proven to be a successful method to stimulate the transfer and use of aerospace technology in the industrial and commercial sector of the economy.

A special seminar on advanced materials research was hosted last fall by the Langley Research Center as part of this seminar series. Over 200 corporate executives and R&D managers attended. A wide variety of papers describing new materials research efforts in NASA were presented by scientists and engineers from various NASA centers. Direct contact with NASA researchers has also been encouraged through these seminars, leading to the development of close relationships between industry and NASA technologists. This is a key ingredient in the encouragement of the use of aerospace technologies in the industrial and commercial marketplace.

TECHNOLOGY APPLICATIONS - 1.8 Million

Another important element in the Technology Utilization Program is the process of adapting aerospace technology to significant public sector problems through hands-on technology assistance. The significance of the problem, whether it be federal, state or local government agency, the private sector or a university and their willingness to finance the majority of the expense of the transfer determines which projects we will develop. It should be noted that we work closely with the user from the project definition stage through development and demonstration of concept; but require the user to staff and fund field testing or clinical investigation. This method allows us to effectively and rapidly transfer aerospace technology and concepts.

During 1982 we completed 10 applications projects and 4 pre-engineering studies. In fiscal year 1983 our emphasis will be to complete on schedule those projects maintaining major user support and conduct pre-engineering studies as opportunities are identified and assessed.

Let me now review some of the recent highlights, accomplishments and plans in our applications area.

State Assistance

A potential, future state, industry and federal government cooperative venture is under negotiation. NASA is currently in the process of initiating an integrated, cooperative wastewater treatment project with the Environmental Protection Agency, State of Maryland Department of Natural Resources, Virginia Institute of Marine Science and the Shell Fish Industry of North America, for disposing of crab scrap. The disposal of the crab waste in land fill, or use as an animal food additive will shortly be discontinued in the Eastern Shore Communities in Maryland and Virginia, leaving no alternate disposal technique. The NASA approach will be to investigate and implement a pilot program to demonstrate that crab scrap could be digested and handled in a waste water system, using the anaerobic filter concept and beds of phragmites (reeds), developed at the National Space Technology Laboratories in Mississippi.

Mission Agency

The Library of Congress has made a unique use of NASA facilities to preserve a national heritage. During 1982, NASA and the Library of Congress completed the Library's first large-scale mass deacidification (preservation) experiment. The experiment was intended to test whether as many as 5,000 books could be successfully treated at one time. The chemical treatment is aimed at extending the life of book paper from a few decades to several hundred years. Using a large NASA vacuum chamber at the Goddard Space Flight Center (GSFC), originally designed to test satellites destined for outer space, a patented process developed by the Library's preservation scientists was employed. The process involved use of a chemical vapor, diethyl zinc (DEZ), to permeate the books and neutralize harmful acids destructive to paper, while leaving an alkaline reserve to combat the return to an acidic condition in the future. Judging by the results to date, the Library will pursue its plan to build a new plant in the Washington area that can handle batches of 15,000 to 20,000 books per treatment. The treatment services will be made available to other libraries and archives.

The National Eye Institute and the Research Triangle Institute (RTI) Applications Team developed a problem statement to address a unique problem facing eye surgeons. The Team disseminated the statement to NASA centers for a possible solution. As a result of the center technical response, NASA Jet Propulsion Laboratory (JPL) and Marshall Space Flight Center (MSFC) are working with the McGee Eye Institute to design a real time instrumentation for gauging the topography of the cornea. When preparing patients for eye surgery, it is essential to accurately measure the pre- and post-operative cornea curvature. With industry involvement, NASA technology in digital data systems and digital video displays is being transferred to the field of opthalmology. The unique feature of the NASA design stems from the use of new technology in solid state imaging, light sources, fiber optics, and data processing.

Robotics

NASA/JPL has been working on robotics developments for the lunar and later Mars lander projects since 1972. One of our Application Teams, seeing the results of this work, arranged for industrial representatives to meet with JPL scientist and teleoperator engineers. As a result of these meetings, NASA's JPL and Unimation, Inc. entered into a three-year cooperative project to equip an industrial robot with proximity sensing capability.

In this project, JPL initially evaluated and tested various sensor designs. As a result of this initial work a best design was selected for integration into a robot for industrial demonstration and field trials. In addition, measurements of parameters important for sensor design have been obtained. Unimation is providing the industrial robot and engineering consultation. They are also developing the appropriate software and controls required by a sensing robot and will fund and staff appropriate field trials and demonstrations. After completion of the work, Unimation has agreed to participate with NASA in a workshop designed to bring these developments to the attention of other American robot manufacturers.

Nondestructive Residual Stress Analysis

Significant costs to industry accrue annually due to metal failures resulting from residual stress. The rail transportation industry has identified $80,000,000 per year as direct and related costs resulting from railcar wheel failures attributable to residual stress failures/maintenance. National costs, due to metal failure in all other categories, are estimated to be more than ten times greater. Other areas of potential impact include stress in rails, wings, turbine discs, bridges, high pressure vessels and other loaded metal structures.

NASA is cooperating with the Federal Rail Administration and the University of Houston to apply aerospace state-of-the-art theory and technology in the field of ultrasonic measurement of stress to the determination of residual stress in metals. Historically, measurements of absolute material properties have been used, with very limited success, to try and detect internal stress in metals. The NASA approach will examine the rate of change of the velocity of sound within the material, as a function of loading, as a more practical tool for detection of residual stress.

Redox

A unique energy-storage system called Redox has been invented and developed at NASA's Lewis Research Center under a program jointly funded by U.S. Department of Energy and NASA. Because of promising recent technical developments and industry interest, NASA TU is presently considering, through an applications notice, a joint cooperative agreement with industry to complete the development and commercialize this technology.

The Redox system is essentially a battery with liquid electrodes that are pumped through a reaction chamber. Because this feature eliminates the major causes of battery failure, e.g. slumping electrodes, plate buckling and grid failure, it is expected that Redox would have a very long life. Some other potential advantages of Redox are:

- o The energy storage (liquid tank size) and power output flow cell (reaction chamber) size can be independently sized to meet a need.
- o The system state of charge is easy to monitor.
- o Although the reactant fluids are acids, with normal industrial control practices, accidental spills should have minimal environmental impact.
- o Cost is potentially low because of system simplicity and versatility, ease of operation and predicted component life.
- o Because Redox is a liquid system, heat rejection is simplified.

Rehabilitation

In response to the recognized national need for the application of technology to the needs of the handicapped, NASA has for several years conducted a special program in the rehabilitation area. The basis of our involvement in these areas lies in the National Space Act of 1958 and amendment, Conference Report 95-1509, August 17, 1978. In addition, Public Law 95-602 "Amendments to the Rehabilitation Act of 1973" identifies additional specific areas of cooperation between NASA and the National Institute of Handicapped.

An Agency heavily involved in the rehabilitation of the handicapped is the Veterans Administration (VA). In order to ensure the broadest application of our technology to the rehabilitation of the handicapped, NASA is presently negotiating a Memorandum of Understanding with the VA. Current on-going and new identified areas of cooperative applications engineering are:

- o Application of cooling garments to certain handicaps
- o Lunar Rover Hand Controller as a driving aid
- o Orientation & Mobility Aids for the Blind
- o Use of Aerospace Simulation and Human Engineering
- o Automated manufacture of prosthetic and orthopedic appliances
- o Functional Electrical Stimulation applied to restoration of limb function

Bioengineering

Working with the medical community, the National Institutes of Health (NIH), the Food and Drug Administration and industry, NASA is also continuing to make significant progress in transferring space technology to develop devices and techniques to improve the quality of life of those with medical disorders.

In the following examples, I will update two of our current efforts in this area:

Today many people are familiar with cardiac defibrillators -- the twin "paddles" emergency medical personnel apply to the chest of those who are suffering a heart attack. Not widely known is the fact that some 10 percent of those who survive a first heart attack subsequently die within a year from a second attack, frequently because they are not defibrillated soon enough. NASA, in cooperation with the Johns Hopkins Applied Physics Laboratory (APL), Dr. Michel Mirowski of Sinai Hospital in Baltimore, and Intec Systems, Inc. has collaborated in the development of an automatic, implantable defibrillator (AID). When AID, which is implanted under the skin and has electrodes connecting it to the heart, detects cardiac arrhythmia, known as "ventricular fibrillation," it automatically supplies an electrical defibrillation shock directly to the heart at less than 10 percent of that required by the external "paddles." AID is intended only for those persons who have survived a previous heart attack and who are judged to be high risk candidates for a second attack. As of December 15, 1982, 104 of these devices are implanted. In 36 patients, a total of 74 ventricular tachycardia and 10 ventricular fibrillations have been converted automatically. An external recorder, similar to a flight recorder on an airplane, also accompanies each patient to store information on heart activity prior to defibrillation.

Under sponsorship of the Goddard Technology Utilization Office, work is underway at APL to develop an improved version of the AID, which will be more versatile, treat different arrhythmias in addition to ventricular fibrillation, remove the need for the external recorder, and remove the need to operate on the patient in order to adjust the parameters of the detection and treatment programs stored in the electronics inside the implanted device.

Another example is a Programmable Implantable Medication System (or PIMS) -- a microminiaturized, computer-directed system for delivery of medication to target organs, in precisely controlled amounts, on individually determined schedules, from a source within the patient's body.

Millions of people suffer from diseases such as diabetes, hypertension, mental illness, epilespsy and intractable pain which can be treated with various medications. Incomplete patient compliance, whether accidental or deliberate, can result in overdose or under-medication, causing possible serious effects. Further, some medications are commercially available in such small amounts that they must be administered as near the target organ within the body as possible. Others have multiple, widespread effects -- both of which can be better used if administered in small amounts near the intended target. Moreover, PIMS will deliver the medication in amounts and on a schedule determined for optimal clinical results, without requiring repeated action by the patient.

Digital circuitry similar to that of the proposed MAGSAT satellite was used in the design of the electronics inside the implantable part of PIMS. The communications link between the implanted device and the attending physician is based on GSFC and APL's experience in designing small satellites. Companies involved are: Novo Research Institute of Copenhagen which develops a special concentrated insulin; Wilson Greatbatch, Inc. which is developing the batteries; Parker Hannifin which is developing the fluid handling systems; and Pacesetter, Inc., which is the producer of the integrated commercial device.

Initial production units for clinical evaluation will be tested by Dr. Richard Sherins at the National Institute for Child Health and Human Development (NIH) and by Dr. Christopher Saudek, of Johns Hopkins, who is funded by the National Institute of Arthritis, Metabolic and Digestive Diseases (NIH). Several important tests are nearing completion. Currently four pumps are implanted in animal models and all are functioning well. We expect the NIH sponsored clinical test will begin soon.

An early spin-off of the project is the "MICRO-MED," developed by Parker Hannifin. The MICRO-MED is an external device to deliver insulin to the patient automatically, thus minimizing compliance and providing a more efficient means of delivering insulin. The device is already undergoing clinical evaluation.

Application Team

A NASA contractor Applications Team will continue to link the user community with NASA scientists and engineers by acting as a link between the user community, federal agencies, institutions, manufacturers and industrial organizations. The team is interdisciplinary and frequently operates on a task basis, offering a matrix of scientists, engineers, technologists and market experts to assist in the brokerage process. The principal responsibilities of the team are (1) to identify and interpret national trends and technology-related problems; (2) to identify potential opportunities to solve these problems with aerospace technology; (3) to work with NASA to screen for the best candidate; and (4) to assist in the risk assessment, commercialization strategy and identification of potential manufacturers, when appropriate.

The team is a necessary part of our system to expedite the transfer of technology by linking public sector users, industry and NASA together to achieve optimum and meaningful results.

SUMMARY

In conclusion, Mr. Chairman, as noted earlier, the Technology Utilization budget request for FY 1984 is $4.0 million. While this constitutes a reduced program level, we feel confident that an effective and cost-efficient program can be maintained. Moderate funding levels in the past have created a cost-conscious approach to the program and have necessitated careful analysis of program options in pursuit of technology utilization objectives. We are proud of this record and are firmly committed to carry on this tradition.

Response to Written Questions from the February 10, 1983, hearing at which Mr. Philips and Mr. Allnutt testified.

QUESTION L-1:

a. Funding for the T.U. program is decreasing. Is it your intention to eliminate the TU program? Why?

b. If you eliminate T.U., how do you plan to comply with section II of the Stevenson-Wydler Act (which requires each Federal agency to establish an office to transfer technology)? Does the reduced T.U. program in the requested 1984 budget satisfy the Stevenson-Wydler requirements?

ANSWER L-1:

a. NASA does not plan to phaseout its Technology Utilization Program. On the contrary, NASA is strongly committed to the objectives of technology transfer and will continue in its effort to maximize the effective utilization of aerospace-developed technology in the public and private sectors of the economy. It is felt, however, that NASA can maintain an effective program through the employment of consolidation, centralization and modernization techniques.

b. We believe the NASA Technology Utilization Program will continue to satisfy the requirements of the Stevenson-Wydler Act. As you know, NASA has always had a highly respected and recognized program of technology innovation and dissemination in effect and has historically chosen to waive compliance with the specific provisions of the act on the basis that our preexisting efforts are in keeping with the intent of the Act. We have again elected to waive the specific provisions for FY 1984. NASA does plan to continue to support a Technology Utilization Office at each NASA field center which will provide technical assistance and disseminate information on technology to state and local governments and the private sector. We will continue to review and assess new technologies for their commercial or other spin-off potential, and to follow up on those assessments with appropriate targetted information and transfer of projects to private and public sectors. We will also continue our publications program, and we will continue to support as many of our regional centers as possible and provide data and technical assistance to those centers which can operate without NASA funding. In addition, we will continue to conduct, sponsor or provide technical support and information for conferences, seminars, etc., to acquaint public and private sector decision makers with leading NASA technologies.

QUESTION L-2:

a. Some of the T.U. program successes have been in areas remote from space programs (e.g., the ultrasonic bolt monitor used in coal mines). Without a vigorous NASA outreach program, how would you expect industries to know about NASA-developed technologies?

b. Your budget justification (page RD 11-4) shows that "Technology Dissemination" activities will decrease from $5.7M in 1983 to $2.2M in 1984. Also you say that you will maintain the same price levels "so that access by small business users will not be seriously impaired." Just how will this work? Do you think that the large companies will step aside and let the small companies have access? Something has to give!

ANSWER L-2:

a. NASA plans to continue to interact with other mission-oriented Federal agencies, such as the U.S. Bureau of Mines, to identify specific problems/opportunities for transfer and application of NASA-spawned technologies, such as the ultrasonic bolt monitor. Applications projects, jointly sponsored by NASA and these agencies, will at the same time require direct involvement of industry as a project partner. The purpose of industry involvement is twofold: (1) to familiarize industry with the technology and its intended application(s), and (2) to assure downstream commercial production once project feasibility and applicability has been demonstrated. Participation by industry in this manner will be solicited broadly in accordance with standard procurement practice. Results arising out of successful applications projects are then broadly disseminated to other industrial sectors through the NASA Tech Briefs program.

b. Under the proposed centralized approach to providing technical information resources to industry, no preferential treatment will be accorded large industrial firms. In fact, large company needs generally differ from small business needs and tend to cover broader "survey-type" information search capabilities, whereas searches for small firms tend to be more highly focused or tailored and less frequent than for larger firms. Information search strategies to support large companies can, therefore be oriented toward a production-line operation which requires less direct manpower, but more computer time on off-hour basis, thus freeing up technical staff personnel in the dissemination center to handle the more specific information needs of small business clients. While NASA cannot guarantee continuation of affordable price levels for small business firms (particularly in the face of rising manpower and data base costs), we are sensitive to the economic circumstances faced by small firms and will make every effort to maintain reasonable and affordable prices.

QUESTION L-3:

You plan to end your studies of U.S. Industry to find where aerospace technology could benefit them (page RD 11-4).

a. Are you satisfied that you understand Industry well enough now?

b. What happens when Industry changes? i.e. We are pushing for more high-technology Industry, might not NASA technology be more applicable tomorrow? How will you know if these studies are ended?

c. What if NASA develops a new technology next year that is applicable to industry? How will you know if you don't keep your industry studies current?

ANSWER L-3:

a. Although NASA has had considerable experience with technology applications and transfer to industry, it would be difficult to say that we can always be in touch with the fast moving industry of today. Though we clearly will cut back our level of study, we do intend to make greater use of our relationships with professional associations, trade associations, professional societies and the like, to stay abreast of industry activities and needs.

b. Based on NASA's experience with industry, past studies, current application center activities and field center technology utilization programs, we feel we can continue to adequately remain aware of and serve industry (including high technology) requirements. NASA currently provides approximately one-third of the funding for the applications centers. We are currently reviewing methods by which these centers can be retained by an alternate means of support, for example, increased state government support, university support or support from user fees. Additionally, NASA is looking at various ways to further automate these centers to make them not only more cost effective but more efficient.

c. The proposed FY 1984 budget will allow NASA to continue the technology utilization program at the field centers. The interaction between the field centers and contractors will not change. We will continue to acquire new technology developed at our centers and by contractors, package it and disseminate it. The review of New Technology Reports for commercial potential, now performed by SRI International under contract, will be continued; therefore access to technology will be unchanged at the FY 1984 budget level. Additionally, with the AIAA, we will continue to hold conferences on leading technologies, which have proven very successful forums for information exchange. We currently are planning a NASA/Industry conference on Fibrous Ceramics Materials at Johnson Space Center in March of this year and believe we will attract the nation's top ceramicists.

QUESTION L-4:

What is going to happen to your cooperative program with AIAA under this budget?

ANSWER L-4:

NASA's cooperative program with AIAA will be continued, but at a reduced level. We are looking at creative ways to sustain this useful program through means such as fees for conference participation, and the like.

QUESTION L-5:

I am interested in your emphasis on biomedical applications as stated in your budget justification book (page RD 11-4).

a. Can you explain an example of your work?

b. A significant part of our Federal budget problem is due to soaring health costs. And many observers feel these costs are due in part to the use of high technology to combat chronic or terminal illness. As a result there is more emphasis on preventive care. How would you characterize the NASA program in this regard?

ANSWER L-5:

a. A classic example of our work in biomedical applications is the Programmable Implantable Medication System (PIMS). A number of chronic diseases require long-term infusion or frequent injections of medication. An implanted pump has been used for the continuous, intravenous infusion of heparin in patients for more than 24 months. One million diabetics in the United States alone depend on daily insulin injections to help control blood sugar levels; one in 10 of these is a child. A programmable implantable pump capable of several delivery rates would be extremely useful in the infusion of insulin to treat diabetes. A more reliable control of blood sugar levels throughout a diabetic's life is thought to diminish the incidence of the complications associated with diabetes -- kidney disease, diabetic retinopathy, atherosclerosis, and heart attacks. Other potential diseases that this system could be used for are listed with the U.S. statistical prevalence of the disease: hemophilia (18,000), hypertension (34,000,000), terminal cancer (500,000), mental illness (600-900,000), epilepsy (2,000,000), intractable pain (1,700,000).

With NASA technology, a miniature, implantable infusion pump that will accurately deliver medication at a programmed rate, is being developed with several U.S. industries. The development of this project should result in the U.S. leading in the field of implantable medication infusion systems.

The NASA technology for the Programmable Implantable Medication System (PIMS) comes from two NASA centers - GSFC and MSFC. The technology is (1) Microminiaturized hybrid circuitry, component selection and space-type reliability and quality assurance techniques that have been developed to provide an extremely high degree of reliability for orbiting spacecraft and CMOS digital circuitry similar to that used on MAGSAT; (2) Command and telemetry systems with functions similar to those used on small, astronomy satellites and other spacecraft and (3) Aerospace technology in miniaturized, highly reliable hydraulic systems similar to the "peanut valve" used in the Viking program. NASA provided the technology, program management and a small amount of

resources; however, the bulk of manpower and financing has come from Parker-Hannifin, Pacesetter Systems, Wilson Greatbatch, NOVO and the National Institutes of Health. The Johns Hopkins Applied Physics Laboratory provides project management for NASA and the Johns Hopkins Medical Institution provides for animal and human clinical trial under the National Institute of Health (NIH) sponsorship.

The project is a four-year project, with the first year consisting of a feasibility and definition study. Hardware development comprises the 2-4th year which includes the animal implant tests and systems validation and the first human implant later this year. A new business Parker-Hannifin/Biomedical Products Division and a new product "MICROMED" have already spun-off from this project.

b. As seen in the above example, the Programmable Implantable Medication System (PIMS) has the possibility of preventing many diseases from becoming chronic or contributing to other diseases because the primary disease is difficult to medicate. Other projects provide solutions which if left unsolved would render the patient functionally incapacitated or unable to return to the work force and society. These range from urinary incontinence (1.3 million Americans), deaf and hard of hearing (13 million), heart attack victims (400,000 annually), etc. As our studies lead us to problems of a diagnostic nature that can be solved by NASA technology, we pursue a cooperative program with the mission agency and industry to transfer the technology. Current projects of this nature are with the National Eye Institute and the National Cancer Institute. Because of our Technology Utilization Program at each of our centers, we are also able to help the Federal Drug Administration (FDA) and other agencies with specific diagnosis of materials, electronics or related problems that they cannot be solved with inhouse technology.

The NASA biomedical program does contribute to preventive care. Preventive care other than that described above is best characterized as devices lending themselves to early diagnosis of disease or the development of software, hardware or methods that inhibit progression of the disease and or secondary complications. Over the years NASA projects have assisted U.S. industry in the development of numerous technologies that include: medical ultrasonics, emergency medical monitors and warning systems, EKG instrumentation, emergency room instrumentation, automatic eye diagnostic instrumentation, prosthetic devices, automatic cell counters, medical image enhancement technologies, improvement in x-ray technologies, medical monitors and biotelemetry systems, cardiovascular and other physiological technologies.

Current ongoing projects are lending themselves to early diagnosis of heart/lung and eye disorders and early detection of certain types of cancers.

QUESTION L-6:

On February 3, Mr. Beggs testified that the agency has "two primary (TU) program objectives" -- (I) industrial and productivity and (II) "quality of life and workforce through bioengineering and rehabilitation projects". On the other hand your budget book refers to a focus on "biomedical" and "a small effort in industrial automation". Can you clarify this apparent discrpency?

ANSWER L-6:

The Technology Utilization program places heavy emphasis on bioengineering and rehabilitation only in the applications projects. This is in response to Amendment 95-1509, August 17, 1978 to the NASA Space Act of 1958; and, Public Law 95-602. In this program, however, there is a balance between bioengineering, rehabilitation and manufacturing (industrial automation).

In the dissemination and analysis activities, the emphasis changes rapidly to transferring opportunities to benefit U.S. Industry as a whole. The actual ratio is close to 3/4 Industry; 1/4 bioengineering and rehabilitation.

Mr. VOLKMER. Very well. I will start with Mr. Bateman.

Mr. BATEMAN. Thank you, Mr. Chairman.

Mr. Philips, I focused in the prepared statement on the industrial application centers and the funding levels for fiscal year 1984 that are proposed. As I understand what I have seen, the requested funding level is $4 million this year and $1.8 million of that is for the industrial application centers.

Mr. PHILIPS. Mr. Bateman, the proposed budget of $4 million would be split between our two basic elements—technology dissemination and technology applications.

Technology dissemination would take $2.2 million, the balance, $1.8 million, would be devoted to technology applications. The centers that you refer to are in the $2.2 million dissemination program.

Mr. BATEMAN. They are in the dissemination area?

Mr. PHILIPS. Yes.

Mr. BATEMAN. Does this represent increased or decreased appropriation or levels of activity?

Mr. PHILIPS. With the proposed fiscal year 1984 budget, we would be required to reduce the level of activity in the dissemination program, specifically in the industrial application center portion of that program.

Mr. BATEMAN. Is that sound public policy to reduce in the area of dissemination of information that gets technology into the mainstream of applications?

Mr. PHILIPS. We believe it is very important to move our technology into the economy via the commercial industry. We believe, however, that we can do certain things to improve the effectiveness of the dissemination program as it would exist under this budget. There are some modern techniques that we can use that we would

attempt to capitalize upon which would allow us to operate more efficiently and still reach as many industries, individuals, entrepreneurs as possible.

Mr. BATEMAN. Where are the exising industrial application centers?

Mr. PHILIPS. We have 10 of them. I can submit that for the record.

[The information follows:]

INDUSTRIAL APPLICATIONS CENTERS

Mr. John Ulrich, Aerospace Research Applications Center, 1201 East 38th Street, Indianapolis, Indiana 46205.

Dr. Tom J. McRorey, Kerr Industrial Applications Center, Southeastern Oklahoma State University, Durant, Oklahoma 74701.

Dr. Paul McWilliams, NASA Industrial Applications Center, 701 LIS Building, University of Pittsburgh, Pittsburgh, Pennsylvania 15260.

Dr. Robert Mixer, NASA Industrial Applications Center, University of Southern California, Research Annex, 2nd Floor, 3716 South Hope St., Los Angeles, CA 90007.

Dr. Daniel Wilde, New England Research Applications Center, Mansfield Professional Park, Storrs, Connecticut 06268.

Dr. Jams Vann, North Carolina Science and Technology Research Center, Post Office Box 12235, Research Triangle Park, North Carolina 27709.

Dr. Stanley Morain, Technology Applications Center, University of New Mexico, 2500 Central Avenue, S.E., Albuquerque, New Mexico 87131.

Mr. William Strong, NASA/UK Technology Applications Program, University of Kentucky, 109 Kinkead Hall, Lexington, Kentucky 40506.

Mr. Ronald J. Thornton, NASA/Florida State Technology Applications Center, State University System of Florida, 500 Weil Hall, Gainesville, Florida 32611.

Mr. John Gibson, Director, Computer Software and Management Information Center, 112 Barrow Hall, University of Georgia, Athens, GA 30602.

Mr. BATEMAN. There are 10 scattered, I assume, throughout the United States?

Mr. PHILIPS. That is correct. There are nine that are broad-based dissemination centers and one specialized center at the University of Georgia in Athens, that disseminates software programs.

Mr. BATEMAN. What is contemplated in terms of any possible reduction in the number of such centers under this fiscal budget?

Mr. PHILIPS. We have not completed our final thinking on that. We would attempt to maintain at a lower level as many of the centers as we possibly could. We would work with them to seek State aid where appropriate, and to see if they could maintain current levels of activity. If they were to continue, we would certainly continue to provide our data base to them and work with them in any way possible to allow them to continue.

Mr. BATEMAN. I take it this level of appropriation or authorization does contemplate a diminishment either in number or level of activity at the centers.

Mr. ALLNUTT. Or level of support from NASA.

Mr. BATEMAN. Less from NASA.

Mr. PHILIPS. Less NASA support.

Mr. BATEMAN. I assume the premise is that this is justifiable in terms of austerity, priorities for technological innovations as opposed to dissemination of the work product of previous research?

Mr. ALLNUTT. I think that is correct, Congressman Bateman. I think part of the rationale also which relates more to the tech-brief publication that I mentioned, is that we should seek to have the users pay some part of the cost if not all of the cost of that publica-

tion. So, it is not simply the taxpayers supporting it. We now distribute that publication free to the 75,000 subscribers. One of the things we will be working on is seeking some way that we can, either through subscription or some other means, to defray part of the cost.

Mr. BATEMAN. Thank you. That is all I have.

Mr. VOLKMER. Mr. Mineta?

Mr. MINETA. Thank you, Mr. Chairman. I would like to follow up on Mr. Bateman's question if I might.

Since there is funding that is decreasing in this whole area of technology utilization, is it your intention to eliminate the TU program eventually?

Mr. ALLNUTT. No, Mr. Mineta. You may recall a couple of years ago, there was a proposal to phase the program down and then out of existence. At the urging of this subcommittee and upon further review of the program, that decision was reversed. So the budget before you now reflects a decision to fund the program at a lower level but to continue it and not to phase it out.

Mr. MINETA. And does that reduced level satisfy the Stevenson/Wydler requirements?

Mr. ALLNUTT. I think it does. We will still have technology utilization officers at each of the centers. As you know, we have Stan Miller and his associates at Ames. We will have that kind of office still at each center which is one requirement of the act.

We will also have a dissemination program, hopefully funded partially by us and partially by subscriptions. And, we will still have some of the regional centers. I think we will continue to be in compliance with the act. As you know, we file a waiver each year signed by the Administrator indicating that we will not follow that act in its precise terms because of the technology utilization program which we think fulfills the requirements of the act. We plan to file such a waiver for this fiscal year 1984.

Mr. MINETA. You say in your statement you will maintain the same price levels, "so that access by small business users will not be seriously impaired."

But how will this work? Do you think that the large companies will step aside and let the small companies have access? It seems to me something has to give.

Mr. ALLNUTT. It would be important to us to try to maintain the current levels that we charge for the services. This is at the regional centers now, because of the fact that about 65 percent of the companies that seek help from these centers are small businesses. During fiscal year 1984, we intend to study methods either to reduce the number of centers or find new ways of funding them so they could continue to give the services at the same price. This task will be a challenge to us.

Mr. MINETA. You see more of this technology dissemination through the dissemination center network?

Mr. ALLNUTT. Perhaps I should let Ron answer that.

Mr. PHILIPS. When you look at the program across the board, the different products that are produced within the program, such as, the Tech-Briefs, backup packages that support the Tech-Briefs, the dissemination centers and other technology applications, are focused on different segments of the market to some extent. In many

cases, it is easier for small businesses to participate in the Tech-Brief program through subscription, and with the industrial application centers than it is in some other elements of the program. So, that it is difficult to try to quantify in any reasonable way that kind of an answer.

However, we recognize the importance of small business in the innovation process and we will make every attempt to serve small business on the same basis as we have in the past. The prices set in the industrial application center are set to some extent by the market itself for technical information; and that is difficult to adjust even under conditions of some degree of subsidy.

Mr. MINETA. Do I understand that you plan to end your studies of the U.S. industry to find where aerospace technology might benefit them?

Mr. PHILIPS. We will have to substantially reduce that level of activity. However, we have gained considerable experience over the years in the program and we don't believe that we would be completely devoid of intelligence. We will attempt to use other means of staying in touch with fast-moving industry in this country today through professional associations, trade associations, professional societies, and other groups.

Mr. MINETA. Are you saying that you are satisfied that you have an understanding of industry well enough at this point?

Mr. PHILIPS. I wish I could say that; I cannot. There are always things that we should understand better, particularly segments of industry.

Mr. MINETA. Sometimes the buzzword in 1982 was infrastructure; the buzzword in 1983 seems to be high technology and at a point when we are starting to put emphasis on high technology we seem to see resources being turned away from that area. It seems to me, that if we are going to continue to be on the cutting edge and in the forefront we ought not to be backing off.

Yet it seems to me that this is an era in which NASA technology might be even more applicable today and tomorrow. I am just wondering where we will be if these studies are needed.

Mr. ALLNUTT. What we will have to do is to hope, based on the studies we have done to date and based on those centers that we do have now, in addition to the civil servants in the NASA centers, that we will be able to serve people. Ron indicated earlier that we hope to go to more automated serving of the customers of these centers which should enable us to reduce staff. I think one thing we should point out is that only about one-third of these industrial application centers' funding comes from NASA at present. Their other funding is obtained from the fees paid them by the users and by other support they get, whether from universities or State governments. So, what we are talking about is cutting back on the third we provide, not on their total support.

Mr. MINETA. As NASA develops a new technology, how will you know if it can be transferred if you are not kept current?

Mr. PHILIPS. The technology utilization program as it now exists in the field centers, the relationship between field centers and contractor activities will not be changed by the fiscal year 1984 budget request. We will continue to acquire new technology from the contractors, we will continue to acquire new technology developed in

our centers, and we will continue to package that just as we have been doing in the past.

So, we will have the same sustained access to the technology that we have had in the past. There is one thing we should mention that we have started doing and we hope to continue on some basis; that is to hold conferences on leading technologies some of which you heard about this morning in the materials area. We did hold one of these conferences last fall at Langley which about 200 of the top materials scientists in the country attended as well as people from Ames and Lewis. It was very successful. We are planning another one in March in Houston to discuss the ceramic structural tiles used on the shuttle. A bit of the technology that you saw earlier this morning will be discussed.

We think that that conference, conducted in conjunction with the AIAA, will draw some of the best ceramicists across the country.

Mr. MINETA. Was that done under a cooperative agreement with AIAA?

Mr. PHILIPS. That is correct.

Mr. MINETA. What happens to that cooperative agreement under this budget? Does it not go down?

Mr. PHILIPS. It would go down substantially. We will try to sustain it through fees for participation and that sort of thing.

Mr. MINETA. It just seems to me that, with an agency that is supposed to have a great deal of foresight, we are being very shortsighted in some of these areas.

Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you. Mr. Watkins has joined us here today. He is not a member of the subcommittee but very interested.

Do you have any questions?

Mr. WATKINS. I sure do. I want to thank you and members of the committee for allowing me to attend this hearing. I feel like coming home. I served 4 years on this committee before going to the Appropriations Committee. I could probably be best described as the most personally involved Congressman in your area of work of any Member out of 435.

I join my good colleague from California here. I think we are not looking forward with the vision that we need to. You people are sitting there in a beautiful situation and it is hard for me to understand why we are cutting back, or proposing to cut back $5 million.

I would like the committee, if it would, to indulge me a few moments and hope they will think with me, if I might ask the chairman here, because, as we look at your work, I have been personally involved with it, with the IAC's and also very personally concerned about the rural applications team because they are working on several things.

Here is where we are making an error, in where we are sitting today. Basically NASA has utilized the T.U. program only for dissemination. You are wanting, under present conditions, the generation of requests to flow in from people out in the field.

I think—and I agree with my friend from California completely—we are at a time when we need to be pushing technology transfer, not cutting back.

I think the IAC centers are good.

Let me assure you that the rural applications team that I have working in an industrial innovations center is generating ideas. If we stop and just think a little bit on the technology problems out there in society, Mr. Chairman, there are only two ways you can answer a technology problem. Do you know what they are?

If there is an answer to a technology problem it occurs in only two ways. If it can be answered it has to be from a new product or a new process.

Now, there are technology problems out there in every area of the world. The MIT's, the Harvards, do not invent; the Fortune 500's do not invent. It is the farmer, rancher, small businessman, skilled workers.

Unfortunately, and I have spoken to MIT on this, we have a major indictment of most of our programs because we have done nothing to go out and generate and work with their inventions. We have waited for someone to come in. We charge them, double-tax them, basically. They are paying for this whole program; my salary, yours. We are double-taxing that small program if they need help. We would be welcoming them if they need help.

If they have a technology problem the only way they can solve it is come up with a new product or new process.

I have set up an industrial innovation center, a Rural Enterprise Development Foundation, ITRAD. ITRAD has the commission team of NASA. It is beautiful.

Let me show what is there in that area. I have a list of these things, but let me show you something.

Do you know what that is? That is an industrial inspection glove. It doesn't have a seam in it, it is bonded using new technology.

Now, it may not have just exactly come from NASA, but the rural applications team sitting around with others in the industrial innovation center realized they have something here.

Why? Because there is a market of $250 million on this industrial inspection glove that is disposable after you inspect. There is not one seam, not a sewing machine operation on it. They can produce 4,000 an hour at a cost of 9½ cents each.

In a rural depressed area of Oklahoma, with 18 percent unemployment, 68 percent of the people have left, searching for jobs. The per capita income is less than $6,000; not one manufacturing job for men. We are going to start up a little factory making these gloves in an economically rural depressed area of America as a result of a new technology.

Ladies and gentlemen, the model for technology transfer is agriculture. Less than 3 percent of our people in this country produce the food and fiber for our country plus a fourth of the people around the world. That is the only area where we mandated technology transfer; 10 percent of the research money in agriculture utilized through not only dissemination but taking that seed and putting it in the ground so the farmer can see it.

I used that fertilizer to produce more wheat. I used that new seed. But only in agriculture. In other areas of activity we are lagging behind.

My good friend from California, it seems we are divorcing ourselves from high technology. What we are doing is saying that this rural application team, which I asked this group to help me with a

$150,000 grant is studying, in industrial innovation centers, where we are going toward solving technology problems.

We not only are able to go to you and IAC's and others to find technology problems. If you had an idea for a new innovation—everything you see in this room at one time was an innovation; everything you got on was an idea. If you have an idea for a new product, what are the questions you have to have answered before you can get it to commercialization.

You said you had 15,000 patents but you haven't been too successful getting them commercialized. Mainly because we have not tried to generate and commercialize it.

We have only taken the technology and not tried to commercialize it.

In the rural areas in my State I put together an industrial research center and the first question you have to answer if you have an idea for a new product is, "Can I technically build it, can I make that latex without a sewing machine?" If you have the technology to build it and we can get that from you, the second question then is, "Can I market this, is the market out there?"

If you can answer those two questions in the affirmative, you have potentially a new business or industry.

The second thing is you have to have a facility to start it in, not just incubators, because a fourth question is, "Can I have skilled workers to build them?"

So we can incubate until we make sure the cash flow is correct, make sure their inventories are correct, they are economically healthy, then we can spin them out into a rural depressed community like Colgate that doesn't have a chance in the world to ever have an industry unless we give birth to industry.

That is what you can do, if we look at it with a vision and foresight, we can generate.

Why do I say that? Let me tell you what we are doing. This is why I need your help and why I am here today.

All these are lists of things that are being generated. Most ideas will not work, but the law of averages will tell us that they will. Crisis is the mother-of-invention. The application team is needed on the small businessman, farmer, cattleman level, because it is not the MIT's or Harvards that invent. You mash your hand enough and you invent.

For instance, a cattleman came in and said I have a Bolus Gun which is a device where you put pills down large animals. The cattleman walked in and said, "I have a Bolus Gun invention, crude, two pieces of pipe."

The industrial innovation center redesigned it and took it to the cattleman's convention. It is probably going to be marketed.

Where am I coming from? I know many of my people will never have a job. Fortune 500 is not going to come to rural depressed Oklahoma. Why should they? They can do better in other more developed sections of industrial America.

But should we forget an area that has lost most of the people?

I know I am taking some time but I wanted to share this with the committee because I believe we are missing a beautiful opportunity to move our country forward in productivity and in new technology.

I think we should try to do more and I think President Ronald Reagan would want us to do more.

Also, Mr. Chairman, I put together the first free enterprise curriculum on a vocational technical school level, not on a university level but vocational technical school level. Why? Because I am getting every skilled worker-student out there to think in their field of study, their technology problem.

We are going to interface it with the rural application team in the industrial innovation center and young people with their minds working trying to solve technology.

With that technology solved we will have a new product or a new process. A new product or process means a new business or industry, which means jobs.

We should be right there on the firing line.

I wish and wish and pray that the people could see what we potentially have to offer by utilizing technology, utilizing it and generating it and not just disseminating it and saying, "Hey, it is there if you want it." But try to literally go back and generate it.

I think the Congress and this committee has indicated that we want you to do more. Under the Stevenson-Wydler Act, S. 1250, on page 21, we have asked you to do certain things. I would like to read:

> It shall be the function of each Office of Research and Technology Applications, [1] to prepare an application assessment of each research and development project in which that laboratory is engaged which has potential for successful application in State or local government or in private industry; [2] to provide and disseminate information on federally owned or originated products, processes, and services having potential application to State and local governments and to private industry.

By the way, as I mentioned, Agriculture uses about 10 percent of their research for technology transfer. I tried to get 5 percent, then 3 percent, then 2 percent, finally got five-tenth of 1 percent from the other agencies.

You have a mandate to help work on technology transfer under NASA, but we are not doing all that we can under NASA.

I want to encourage you to try to do more. But also to provide technical assistance in other areas.

I would like to ask a question. What are you doing to try to meet this besides cutting all the money back? Are you doing anything to try to do it?

Which way are we going?

Mr. ALLNUTT. We are. If I could respond for just a moment, and then come to your question.

I think what you are doing in your district is important and it is an encouraging thing for you to be doing; we wish you every success.

Mr. WATKINS. Are you going to help me?

Mr. ALLNUTT. As you know, we have funded the rural applications team through one phase and have a proposal from them for a second phase. We are expecting their formal written report from the first phase by the end of this month. We have had an oral report from them.

Obviously, the focus of what we do has to be, as you indicated in reading the act, on transferring the technology developed in NASA

into other operations, not on developing technology directly for other purposes.

Mr. WATKINS. If you will yield just briefly, if you put the right minds together they will emerge using technology of NASA. But they will also work with other technology, too, if you put the right minds together, in a brain trust or think-tank type operation.

A number of these under NASA are using the technology and are searching the technology now. Optical vision, we are bringing on now, going to revolutionize the work of scanners and vision machines, directly used by your program.

Mr. ALLNUTT. When we have the report from the team, from that first phase, and have had a chance to study their proposal, if we think there is an appropriate role for us there and if we have the funds to fund them, if we will try to fund them.

Those are the two questions we have to answer, because we are dealing with limited funds. Whether at the 1984 level or 1983, with $9 million, there is a limit to what we can do.

Mr. WATKINS. I have visited the former chairman and other Members; also the Appropriations Committee, to urge funds for your program and they feel like there should be adequate help there.

Hopefully you will feel the same way.

The taxpayers out there would like to see some effort done on their level, some results.

I think what we are doing is exactly what Ronald Reagan would like to see done: free enterprise, entrepreneurship, technology transfer, building jobs.

Agriculture has done it. I think we can be just as successful if we work at it.

I noticed that you indicated you are going to fund one this coming year. That is the rural application team.

Mr. ALLNUTT. If, when we finish working out in detail how we would handle the $4 million request, what we were trying to telegraph to you is it is likely we would fund only one team which would focus on biomedical activities and second on some industrial processes and not on rural.

Mr. WATKINS. I would like to also state that I notice where they are going to consolidate into about two of them, in highly populated areas of the country, such as the New England area, saying those are the ones that have been able to generate the income.

Basically they are saying, "If you don't have the money, forget it." That is a bad thing.

This administration is getting a reputation as to fairness. If you have, you can do; if you do not have, forget it.

I hope we can kind of dilute that image of this administration a little bit.

Just because an area is rural depressed, no jobs, people moved out, you tell me how we can help those people. Do you have any idea?

Mr. ALLNUTT. Let me respond to the first part of your question. We would consolidate the applications teams into one through a competitive process. We haven't selected the area. It is true on the industrial application centers, IAC's. As you know, the New England center has had a very good record not only of generating

income but of moving the technology very effectively. As we consolidate, we are using that center as a model because it has worked very well.

I don't have an idea of how NASA could be of help, in any broad scale way, across the country to communities such as the one you are mentioning at the kind of funding levels we are discussing.

Mr. WATKINS. We are talking about 500,000 people scattered over a 100-square-mile area, chronically unemployed, under employed, more out-migration than at any time since the Great Depression. Three times I went to California, Norm's State, picking up potatoes, cutting grapes. I did it when I was a kid. That is what motivates me. I want to build a future for our people in that area. I think there is a way. Your program can help. That is why I plead with you to try to help us. Don't turn your back on us because we have one ray of hope and that is giving birth to it, because no one is going to move to our area.

I don't have a corporate data program, Fortune 500, or Silicon Valley. I can. I can if you will help us. We will build a future for those people. I ask you for your help.

I would like to enter some of this information if I could for the record. I would just like to say that you are a diamond in the rough. I am probably your greatest champion. I hope I don't have to lose that enthusiasm because I think you can be one of the greatest phases, a little diamond in the rough if we can all have the foresight to work together to try to do it.

I ask you to take a close look at it and give us a chance to prove to Americans and to the people that we can lift ourselves up by our bootstraps in a low economic area of this country.

Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you. I thank the gentleman from Oklahoma.

Mr. NELSON. I just want to say to the gentleman that I still have my enthusiasm for NASA, but as to some of the potential policies that they have going on down at the Kennedy Space Center, they are straining the limits of my enthusiasm.

I want to yield to my colleague from California in 1 minute for an example. I want to make my case for you why I think this is counterproductive.

In addition to what the gentleman from California and the gentleman from Oklahoma have both shared with you, we are talking about a budget in fiscal year 1983 of $9 million, and we are talking about a budget request now for fiscal year 1984 of $4 million for this particular item.

I think I would make the case by recalling that Time magazine's man of the year was a machine, and what this computer on the cover of Time magazine was symbolizing was that the future direction of this country is into the high technology area. Some of us known as Atari Democrats here at this table have some glimpse of that vision.

I think in fact it is true that the competitive edge of America in the future is high technology. NASA has been absolutely essential to this. We are going to have difficulty competing in the world markets in such items as steel, automobiles, textiles, so forth and

so on. But in high technology we still have the lead, if we don't give it up.

Now, let me transgress back into history. It was the Apollo project that did so much for the transfer of technology into our everyday lives, and indeed into the operation of corporations in this country. We have seen the fruits of that technology development and that technology as it has been transferred.

Therefore, when we are getting ready for this onslaught of intense competition in the world markets on technology, it seems to me that NASA, as one of the main developers of technology, needs to transfer that as much as possible. At the same time I want to give you a practical reason, from your perspective as an Administrator in NASA, for why you want to do this:

It is one of the best public relations gimmicks that you could have. This kind of book right here. You get that out to every library in the country, every school library. Let kids start seeing what America's space program has done for them, and you will get us into a position that when we have to translate your requests into votes for dollars and authorizations, appropriations, the job for us is going to be made so much easier because the contents of all of these—Congress really doesn't know very much about the space program—are going to tell them.

So that is a practical reason for you to do that. I think you have been improving. Back in the days of Apollo, save for the glamour on television of our landing on the Moon, shortly thereafter into the decade of the 1970's, NASA didn't do a very good job on public relations.

I think you are coming out of that. But now that you have this momentum building and you have some glamour on TV screens of America, why give up the momentum? Why not build on that momentum of the success of the shuttle in showing what the practical applications of this are?

Now let me yield to my colleague from California. He wants to give you a particular rebuttal to where you think private small business can in fact develop this technology and utilize it without your transferring it to them.

Mr. MINETA. I thank my colleague from Florida.

The thing that bothers me is that innovation and new jobs have generally come from small business. That is where we have done a lot of innovative things, and when you look at the statistics on new job creation it has been in the area of small business.

Yet we are going to keep the price levels the same, essentially. Hopefully, in describing the dissemination centers, you are talking about maybe State financing picking up where we can't do it. The States are in financial trouble.

Then you go on to show how your program is working and then you give the example of Shell Oil. Hardly a small business. It just seems to me when you talk about utilization of what comes out of the software program and is disseminated through cosmic. Then you say Shell Oil used a software package developed by JPC.

To me, when I think about job creation, in terms of innovation, it seems to me we are just shying away from the people who ought to be the cutting edge in this whole area. That is small business. Yet we are caught.

Mr. ALLNUTT. I have you at a disadvantage, Mr. Mineta, because you had to take a call a few minutes ago. During that brief time that you were away, I mentioned a counter example to the Shell one, though it is best we help all of our industry.

I mentioned the Inductron Corp. from Grafton, Va., and Dave Brown, who runs the Dave Brown Canoe and Kayak repair outfit at Great Falls is another kind of example. We want to help the Dave Browns in the country.

You didn't yield to me, Mr. Nelson.

Mr. NELSON. No; go ahead.

Mr. ALLNUTT. I think your point is very well taken. As you are saying, and as Mr. Beggs said during the full committee hearing the other day, the most important thing for us to keep up is the total level of research and development in both the public and the private sector in this country. We have dropped from a level of 3 percent of the gross national product in the 1960's to 1 percent now being devoted to research and development. Maybe that is why when we see ourselves losing the edge in so many industries we might have to look no further at than that to determine what is going wrong.

But whether we spend 1 or 3 percent and whether the Federal part of that is 50 or 60 percent, it is also important we make the most out of that technology. That is the whole reason this technology utilization program was started 20 years ago in NASA, with the realization that we weren't simply developing that technology to go to the Moon or we were missing a boat; that we should develop it to help industry in this country.

It is on this basis that the technology utilization program was started and has been continued. So, it is important that we worry about and that this committee worry about the total level of research and development spending in the country, the total level of Federal support for that research, the total level of the NASA budget, and the level of the technology utilization program that tries to take the output of that one small part of what the country is doing to insure that the benefits are spread as widely as they can be across the country.

So that is a long-winded way of agreeing with you.

Mr. NELSON. Can you tell me: What was this about a dissemination center in Florida being closed? I will just get right to the point. I am a little sensitive about comments like that these days.

Mr. ALLNUTT. I wanted to agree with your overall observations before we got to the Florida situation. But we will have to consider how many of the application centers we can continue at $4 million and at what level of funding we can continue them.

What we tried to say, or Ron tried to say in his statement, was that we will be looking for greater support from other sources for these centers. On the average, they are about two-thirds supported by funding other than NASA funding. We will be looking to increase that percentage of support and Florida is one which is doing a good job. We think we have a good chance of getting additional funding from sources other than NASA. We hope that is the case and we will work with that center to try to make it a reality.

Mr. NELSON. Is that center at KSC?

Mr. PHILIPS. No, it is associated with the State university system.

Mr. ALLNUTT. As you know, we also have a technology utilization office at KSC, and that would continue.

Mr. NELSON. I am thinking back to 2 years ago, sitting on the full Science and Technology Committee, and the thrust was we are going to cut back in energy research and development. This was the committee's proposal in fiscal year 1981. That was because Government funding for research and development can in fact be cut back because private industry will step into the breach. Now, 2 years into the new administration there is considerable back peddling on that initial philosophy because, in fact, it has been demonstrated that private industry won't step into the breach in many cases that the committee thought it would.

I see an analogy between that reasoning and this reasoning. Your statement here that State governments, as the gentleman from California has pointed out, will step into the breach. That is just simply not so at this particular economic time. I am afraid that it is a fact of life that the Federal Government which has been, through a marvelous agency such as NASA, so successful that the Federal Government has a role to help demonstrate and transfer technology and we will all be beneficiaries by it.

With my colleague here from California, I will close with this statement, Mr. Chairman, getting back on the P.R. thing: It was 4 years ago that Norman Mineta and I were able to produce a one vote margin in the Budget Committee, which asked for a waiver on a supplemental for NASA of $185 million. We barely got that through the Budget Committee. Now, as it turned out, it should have been a supplemental of $485 million instead of $185 million. The fact is that it was back in that era when it was so easy to take a swipe at NASA because there had not been that chronicling successfully of NASA's achievements in the development of high technology. People did not understand how it applied to their everyday lives. I really think you ought to continue that effort that you are beginning successfully now.

Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you, Mr. Nelson.

I would like to know, 2 years ago, as I remember, the budget request was for $4 million, is that correct?

Mr. ALLNUT. That is fiscal year 1981?

Mr. VOLKMER. I am talking about fiscal year 1983. For this year it is $4 million that we are in right now.

Mr. PHILIPS. That is right.

Mr. VOLKMER. The Congress came along and said no, we are going to give you $9 million.

Mr. ALLNUTT. Yes.

Mr. VOLKMER. How much are we spending?

Mr. ALLNUTT. We will spend the full $9 million. We intend to proceed with the $9 million as authorized and appropriated.

Mr. VOLKMER. Then there is no question that we are going to see quite a bit of reduction, and he told us about some of those centers being closed, things like that. There is no question in my mind from the comments of most of the people here on the committee, that they foresee this as a reduction in our effort for technology utilization.

Mr. ALLNUTT. That is correct. It is necessarily a reduction in that effort at this budget level.

Mr. VOLKMER. And to be honest with you, along with a majority, it just doesn't make sense to some when we say we have to increase our technology development, but cut back on technology utilization. I understand where you are coming from, but let's put it this way: In the event that the Congress would see fit to provide you with the same amount, taking inflation and everything else into effect, would you be able to utilize those funds?

Mr. ALLNUTT. Yes, I think we would, Mr. Chairman. But as you understand, we are not requesting more funds in fiscal year 1984.

Mr. VOLKMER. I know you are not requesting it. You didn't request it last year.

Mr. ALLNUTT. That is right, sir.

Mr. VOLKMER. I notice, too, the gentleman from Florida mentioned, in your statement, Mr. Philips, that Florida and some of these other States will be able to take over these programs. I don't know the financial conditions of Florida, North Carolina, Oklahoma, New Mexico, but I do have some idea, a little bit better idea of the financial conditions of States such as Michigan, Ohio, Illinois, right next to me.

The paragraph immediately following the one where you say a good chance for contribution of State funds, you say NASA also stands ready to assist other States in their quest for technical information resources to support their objectives in economic and industrial developments. The States of New Jersey, New York, Michigan, Ohio, and Illinois have already expressed interest in the availability of aerospace technology in these matters.

Now, if we see a reduction, how are you going to help those States, Mr. Philips? They are busted, everybody knows that. They are in the red.

Mr. PHILIPS. Yes, sir. We are currently giving that a great deal of thought. I hope I didn't choose the word "will" when I said there was a possibility of State aid. What I certainly meant to say was that we "would" make every effort in conjunction with the industrial application centers, to develop a basis to seek State aid where appropriate and if possible.

Let us take, for example, the case of Michigan. Prior to the last election there was a great deal of interest, and I believe it still exists, in the State of Michigan in the area of automation, robotics.

Mr. VOLKMER. Yes.

Mr. PHILIPS. We at NASA believe that in certain areas, or subfields within the general field of automation, which you heard about this morning, have something to offer the industry. What we had under discussion was a very inexpensive program; a program which would allow folks at JPL to demonstrate the state-of-the-art in those subfields of technology, and through the offices of the State of Michigan to the fledgling Michigan industry, to set up a continuing relationship between scientists and engineers at JPL; as an example, with design-engineering and other people in those small companies in the State of Michigan.

Those kinds of programs can be tremendously effective at any level. It also turns out that they can be conducted on a basis which

it is not terribly expensive. I use that as an example to try to address the general question you asked, Mr. Chairman.

Mr. VOLKMER. The other thing that I want to say is that this magazine, Spinoff, shows the article concerning the gentleman here with you. I have a question I would like to ask you. I don't know the answer but I go back through the process of how these things get into various publications. Are these the only publications that you utilize?

Mr. PHILIPS. Which one do you have, sir?

Mr. VOLKMER. This is NASA Technical Briefs, and the other one is Spinoffs.

Mr. PHILIPS. There are other publications that support the Tech-Brief Journal. The information in the Tech-Brief Journal is primarily information to develop an awareness of the existence of a technology. We have additional publications that support that detailed technical material. So when an individual who sees a Tech-Brief says, "I have an interest in that," there is information about where he can write to get further technical information, that additional technical information can also be obtained from the field center that developed it. It will be mailed immediately to the individual or organization requesting the information. So, yes, there are other publications.

Now the Spinoff on the other hand stands alone. If it does generate inquiries, we respond to those inquiries with additional information with regard to any general or specific areas. We would put them in touch, for example, with the appropriate company or individual represented in that magazine.

Mr. MINETA. Would the chairman yield?

Mr. VOLKMER. After I ask one more question.

Do you have within your Agency, knowledge as to the various journals that the various manufacturers publish?

Mr. PHILIPS. I would say we have a general awareness.

Mr. VOLKMER. Trade journals, periodicals?

Mr. PHILIPS. Yes. I would say we have a general knowledge of many of them and quite specific knowledge of some of the others. Indeed, many of those trade publications republish material that we publish in the Tech-Brief Journal. They take it out in total and republish it in their own journals. We cooperate with them because those trade publications reach a much larger audience than we can reach.

Mr. VOLKMER. That is what I was wondering about. Do you sometimes take an article contained in the Tech-Brief and submit it to them for publication or do you just send them the whole thing and let them decide?

Mr. PHILIPS. We send them the entire journal because it is packaged together and not into disciplinary areas. So, the entire journal would go to a particular trade organization. However, with the increased interdisciplinarity today, that isn't necessarily bad. It doesn't mean the information is wasted. I would not argue that the entire document is useful to a specific organization in every case.

Mr. VOLKMER. Have you looked into the possibility of disseminating those things that may be of interest to those certain trades, sending those specific items to those trade journals?

Mr. ALLNUTT. That is a good thought, Mr. Chairman.

Mr. VOLKMER. Rather than have them say, let's look through here and see if they have something we can use.

Mr. ALLNUTT. One thing we are considering and will be thinking about in the months ahead since the Office of Management and Budget wants us to make this Tech-Brief publication self-supporting, is ways to change what we are currently doing so we can be more nearly self-supporting. That is a good suggestion. We will consider that as one way of doing this.

Mr. MINETA. That is great. We have phrases like revenue enhancement; things such as user tax. Why can't we make this on a cost recovery basis? There would be no reason the companies across the country wouldn't be willing to subscribe for whatever it might be, to these kinds of publications. They would get wider dissemination and at the same time, it is something that would not necessarily be a cost. Then we would be able to retrieve some of those costs and still the dissemination would be there. It seems to me we should be able to do something like that.

Mr. ALLNUTT. That is exactly the kind of thing we are wrestling with now. We have examined those cases of other publications that went overnight from free subscriptions to charging and it is a pretty dismal record. So we are looking for some way to ease into that mode.

Mr. MINETA. I will bet those who are utilizing it are doing it more effectively than having it sit on someone's desk just because you mailed it out to them. Those who are going to be willing to pay the $4 to look at it, are not going to let it sit in their in basket. They will tear it apart and send parts of it around to manufacturing, part to research offices. There is going to be utilization of it instead of sitting there as a nice magazine on someone's coffee table.

Mr. ALLNUTT. I think there is a lot of truth to that, although I think we do get pretty good usage of the Tech-Brief Journal. We get 200,000 inquiries a year based on the ideas published there. So there is a fair utilization of the Journal; but, we might well increase it if we conduct these studies the right way and make the right moves over the next few months.

Mr. MINETA. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you.

I have no further questions. We will adjourn the committee until 10 o'clock on February 22, at which time we will hear from the NASA witnesses on space science and applications.

[Wherefore, at 12:35 p.m., the subcommittee was adjourned.]

1984 NASA AUTHORIZATION

TUESDAY, FEBRUARY 22, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to call, at 10:05 a.m., in room 2325, Rayburn House Office Building, Hon. Harold L. Volkmer (chairman of the subcommittee) presiding.

Present: Messrs. Volkmer, MacKay, Mineta, Nelson, Brown, Andrews, Walker, Bateman, Winn, Chandler, and Lujan.

Mr. VOLKMER. The subcommittee will come to order.

Today we continue our NASA authorization hearings, opening a set of three sessions dealing with space science and application programs. Many of the things that NASA does are in support of science and in support of applications. For example, we need high energy upper stages to take scientific missions to the outer planets, and to take more capable communications satellites up to geosynchronous orbit.

NASA is often described as a mission-oriented agency, and that is appropriate. But we must never lose sight of why we build and fly the missions. We have to keep the end use always before us, for example, this year in the budget it contains a new planetary mission, the Venus Radar Mapper, that is commendable. But it also contains a cut in the Planetary Research and Analysis Budget; in other words, a cut for support of scientists who eventually will use the data from the new Mapper.

We will take a look at that cut to see if there is an adequate support for the scientific community for whom the missions are flown.

Another area of concern is applications. We want to be sure the technology developed is made readily available to users. The remote sensing means doing the research necessary to turn the satellite data into information that users need. Communications means making sure the technology we put into space will be matched with the ground stations needed to deliver messages to customers. In short, we know that NASA is successful in technology development. We want to be sure that the technology is put to good use.

Our first witness is Dr. Bert Edelson, Associate Administrator for Space Science and Applications, National Aeronautics and Space Administration. He will present the 1984 budget and answer questions.

Our second witness is Gen. Lew Allen, the relatively new director of the Jet Propulsion Laboratory at the California Institute of Technology. We look forward to meeting General Allen and discussing with him the future role of JPL.

Dr. Edelson, we will now take your full statement for the record. It will be made a part of the record. If you wish you may read it or you may summarize.

[A biographical sketch of Dr. Edelson follows:]

DR. BURTON I. EDELSON

Dr. Burton I. Edelson became NASA's Associate Administrator for Space Science and Applications on Feb. 14, 1982. He is responsible for the planning, direction, execution and evaluation of the overall NASA programs concerned with space science and applications activities conducted at the Jet Propulsion Laboratory, Pasadena, Calif., and the Goddard Space Flight Center, Greenbelt, Md.

Dr. Edelson was with the Communications Satellite Corp., Washington, D.C., for 14 years, most recently as senior vice president. Previously, he was director of COMSAT Laboratories, Clarksburg, Md.

Prior to joining COMSAT, Edelson was a commissioned officer for 20 years in the U.S. Navy. During his naval career he served in the Office of Naval Research and on the staff of the National Aeronautics and Space Council.

Dr. Edelson is a Registered Professional Engineer, a Fellow of the American Institute of Aeronautics and Astronautics, the Institute of Electrical and Electronics Engineers, the American Association for the Advancement of Science and the British Interplanetary Society. He has been a member of several NASA and DOD advisory boards and served as a member of President Reagan's NASA Transition Team.

He has published a number of technical papers on satellite communications and has lectured on satellite communications in the United States and many foreign countries. He received the Henry Marion Howe Research Medal of the American Society of Metals in 1963, and the Legion of Merit, U.S. Navy in 1965.

Born July 31, 1926, in New York City, Edelson received his bachelor's degree from the U.S. Naval Academy and his master's and doctorate degrees from Yale University.

Dr. Edelson and his wife, the former Betty Good of Havre de Grace, Md., reside in Chevy Chase, Md. They have three children.

STATEMENT OF DR. BURTON EDELSON, ASSOCIATE ADMINISTRATOR FOR SPACE SCIENCE AND APPLICATIONS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY SAM KELLER AND RONALD KONKEL

Dr. EDELSON. Thank you, Mr. Chairman, members of the subcommittee and guests.

I am happy to be with you today to review the space science and applications program and to discuss our proposed budget for fiscal year 1984. The activities I will discuss today continue the tradition of achievement that has already produced so much new scientific knowledge, so many new technological developments, so many practical applications and so much national pride.

I will discuss briefly the proposed fiscal year 1984 budget as well as some of our past accomplishments and future plans. My written statement, which with your permission I will submit for the record, contains more information on these subjects, and I will, of course, be happy to answer any questions that you have.

Before going into the details of the proposed fiscal year 1984 budget, I would like to mention two recent accomplishments. Such achievements are, in the last analysis, the real justification for our programs.

We entered a new era in remote sensing of the Earth with the successful launch of Landsat-4 on July 16, 1982. This spacecraft carried a new instrument, the thematic mapper [TM], in addition to the multispectral scanner [MSS], carried on earlier Landsats. The TM is intended to provide improved spectral data and better

ground detail than the MSS, and the first images have surpassed all of our expectations. I have some posted in the room and there is one on the easel.

This particular one, acquired in August, shows the Mississippi River north of Memphis, Tenn., and we can clearly distinguish the farms on either side of the river. Moreover, images like these will provide much better data for such uses as crop inventories and even the detection of crop disease and other stress caused by drought or disease.

Other thematic mapper images have already demonstrated their potential for obtaining equally important information about bedrock geology, mineral and water resources, and forestry. I must report that late last week an anomaly occurred in the X-band transmitter which is used to transmit thematic mapper images until the operational use of the TDRS's becomes available. In the worst case, foreign ground stations would only be able to receive MSS data and not the TM data. When more information is available regarding this situation we will advise the committee.

Turning from the Earth to the distant universe, I would like to report that on January 25, 1983, we successfully launched the infrared astronomy satellite [IRAS], which is giving us an important new view of the universe. With IRAS, we can now study many cool and cold objects that emit their radiation as infrared rays. Such things as dust clouds, the cores of galaxies, and the very young stars, where planets may be just forming, have now been brought within our sight.

IRAS has been a technically ambitious project, and we have overcome many difficulties in developing the spacecraft and its instruments. But the spacecraft is now fully operational, and the telescope is even more sensitive than we thought it would be. We have already completed a minisurvey of infrared sources along the plane of our galaxy, and we have just started the full sky survey for which IRAS was planned. As you may have noted on the front page of this morning's New York Times, a real harvest of important and very exciting scientific data. Now if I may I will turn to the budget.

The total fiscal year 1984 space science and applications budget request is $1,068 million. As you see in this pie chart (fig. 1), it is divided about equally between ongoing flight programs and our research base. The budget reflects a vital and stimulating program. It supports the continuation of such current projects as the space telescope, the Galileo mission to Jupiter, and the International Solar Polar Mission [ISPM]. It also supports the continued development of the gamma ray observatory [GRO], an important astrophysical mission scheduled for launch in 1988.

The budget also includes important new and expanded activities in three areas: The Venus radar mapper [VRM] mission which will map the surface of Venus; the advanced communications technology satellite [ACTS] project which will develop critical new technology for future communications satellites; and an increase in the Explorer program to maintain our ability to develop relatively low-cost, scientifically important missions in space astronomy.

The details of the budget are given in the two following charts (figs. 2 and 3). I will go through the line items with you, Mr. Chairman.

Starting from the top, the solid Earth observations budget request for the fiscal year 1984 will allow completion of the Landsat-D thematic mapper ground system; allow a large format camera to be developed as part of the shuttle/spacelab payloads development; and provide geodynamics funding to support our efforts to understand the nature of dynamic processes that occur at and beneath the surface of the Earth. The NASA portion of the AgRISTARS program will be phased out. Research and analysis activities will support definition studies of new remote sensing technology and will encourage the use of Landsat-type technologies by both Government and industry.

In the environmental observations area, funding for the upper atmosphere research program will let us continue our efforts to understand better the Earth's upper atmosphere. A major part of this effort is the upper atmosphere research satellite experiments [UARS], for which design and development activities will be continued in fiscal year 1984. Research and analysis activities will be continued in such areas as: Oceanic processes, atmospheric dynamics, and radiation research, and space plasma physics. The Earth radiation budget experiment [ERBE] activities are continuing in preparation for launches on NOAA and NASA spacecraft in 1984. Mission operations funding will support operation of such existing spacecraft as the solar mesosphere explorer [SME] and the Nimbus-7. A point of special interest is that the International Sun-Earth Explorer [ISEE-3] is being shifted into a new series of orbits to investigate the distant magnetic tail of the Earth. It will be sent to intercept Comet Giacobini-Zinner in September 1985, providing the first in situ measurements of a comet tail.

In fiscal year 1984, the materials processing in space program will continue efforts to use the Zero-G environment to produce new kinds of materials. The STS-7 shuttle flight, scheduled to fly this spring, will contain a new experiment to study crystal growth, metallurgy, and containerless processing in space.

In space communications, a major new effort to develop and test the technology needed to maintain U.S. leadership in space communications. The new project is called the advanced communications technology satellite [ACTS] project, and it will proceed into design and development in fiscal year 1984. The objective of ACTS is to prove the feasibility of new technology, to avoid the problems of orbit and spectrum saturation, and also to enable cost-effective growth in the capacity of communications satellite systems. Some of the critical technologies, such as multibeam antennas and related onboard switching components, have been under development by U.S. industries for the last few years. In order to test and prove these technologies, we will develop an experimental satellite payload to be launched in 1988. Extensive industry involvement is anticipated in the ACTS project, including industry cost-sharing.

The space communications research and analysis activities in fiscal year 1984 will support continued development of advanced technology applicable to a wide range of future communications systems. The search and rescue satellite [SARSAT] system has already been credited with saving 19 lives in marine and aircraft accidents. The second satellite [NOAA-F carrying search and rescue equipment is scheduled for launch in March 1983. Technical con-

sultations on worldwide communications problems will be continued, as will experiment coordination and support for the advanced communications technology satellites [ACTS].

Now, I would like to discuss the science programs, Mr. Chairman. In the physics and astronomy program, the space telescope [ST] project remains the centerpiece of our efforts. Last year, there were several important accomplishments. We have completed coating of the primary mirror. We are now beginning the critical stages in the assembly of this mirror into the overall optical systems of the ST. Excellent progress has been made in other areas as well.

The first scientific instrument, the high-speed photometer [HSP], has been delivered, and we expect delivery of the remaining four instruments beginning this spring. Work on the support systems module is also proceeding on schedule. In a few months, we will celebrate the opening of the new space telescope science institute at the Johns Hopkins University. However, as we should expect in such complex projects, we are continuing to experience difficulties, particularly in the development of the space telescope optical telescope assembly. The effort required to assemble and test this unit is turning out to be larger and taking longer than we had anticipated. We are reviewing a range of actions which address the technical, cost, and scheduling issues confronting the project. As our evaluation of these issues progresses, we will keep the committee informed of the status of the program and of any actions taken.

Development of the gamma ray observatory [GRO], a spacecraft to detect the high-energy radiations from the universe, will be continued in fiscal year 1984, leading to a launch in 1988. The shuttle/spacelab payload development and mission management activities will support continued development of spacelab instruments and integration activities. Explorer development activities will be focused on continued development of the cosmic background explorer [COBE], the active magnetospheric particle trace explorer [AMPTE], and will allow us to start development on the extreme ultraviolet explorer [EUVE].

The physics and astronomy mission operations and data analysis budget request shows an increase over fiscal year 1983 which is largely due to the required buildup in support activities and hardware purchasing for the capability to support operation and maintenance of space telescope. This item also supports data analysis activities from such spacecraft as the international ultraviolet explorer [IUE] and the repair of the solar maximum mission [SMM] satellite.

Research and analysis funding will support a range of ground-based scientific research. The suborbital funding will support sounding rocket, balloon, and aircraft flights for scientific research studies.

In planetary exploration, we are requesting fiscal year 1984 funds to begin design and development activities on the Venus radar mapper [VRM], a new mission to obtain detailed surface maps of the cloud-covered surface of Venus. The radar maps that VRM will produce are essential for geological studies of Venus' surface and interior, just as other surface maps have been essential

for exploring and understanding the other terrestrial bodies—Mercury, Mars, the Moon, and the Earth.

The VRM mission will use a synthetic aperture radar [SAR] to map virtually the entire surface of Venus—about three times the land areas of the Earth—in much better detail than we can now obtain. With this new detail, we can detect small-scale surface features—volcanoes, impact craters, lava flows, perhaps even ancient river channels or ocean shorelines—on Venus that are essential to understand the complex history of Venus and to learn why this particular planet, which is so much like the Earth in many ways, is so very different in others. The VRM mission is planned to be launched in 1988 by the shuttle/centaur combination. In order to obtain the science objectives at a low cost, VRM will use some residual hardware and inherited design from other projects, and a less sophisticated method of operating the spacecraft.

The Galileo development activities continue toward a 1986 launch to Jupiter also on a shuttle/centaur combination, leading to an arrival at Jupiter in 1988. The requested fiscal year 1984 funding will also support development activities on U.S. experiments to be flown on the international solar polar mission [ISPM], and leading to launch of the single European space agency [ESA] spacecraft in 1986.

The planetary mission operations and data analysis MO&DA, funding will support activities leading to the Galileo and ISPM launches in 1986 as well as continuation of operations and data analyses for the Pioneer and Voyager spacecraft. Research and analysis funding will support continuation of the infrared telescope facility in Hawaii and operation of the lunar curatorial facility at JSC as well as a wide range of ground-based planetary research projects.

In life sciences, the research and analysis program will continue to support ground-based research to understand problems related to space physiology and the origin of life. Shuttle/spacelab payload development will be continued to monitor and understand the reactions of humans and other living things to the weightless environment of space. An important series of payloads is scheduled to be flown on Spacelab-4 in 1985, which is the first dedicated life sciences spacelab.

Let me now talk briefly about some of our future plans and strategy in terms of the space science and applications objectives and in terms of scientific discipline we support—astrophysics, planetary sciences, Earth sciences, and life sciences; and the balance of large and small missions. In reaching this balance, we rely heavily on the information provided by a number of advisory committees, such as the National Academy of Sciences' Astronomy Survey Committee and the Solar System Exploration Committee SSEC.

Because of the long time—often several years—needed to define a new mission, we will continue to study a number of future missions that will address a variety of unsolved scientific problems. We are continuing studies on the advanced X-ray astrophysics facility AXAF, which was given the highest priority in the recently published report of the National Academy of Sciences' Astronomy Survey Committee, "Astronomy and Astrophysics for the 1980's." We are continuing our studies to define AXAF so that astronomers

will have the higher resolution X-ray observations needed to understand the details of such changing and violent objects in our universe such as quasars, black holes, and the centers of galaxies. We are also beginning definition studies for the shuttle infrared telescope facility SIRTF, which will follow up the IRAS observations of the cooler regions of our galaxy and other extra-galactic objects. There are more details on these potential future missions in the written statement.

The space science and applications program has a long tradition of achievement, and the fiscal year 1984 budget represents a commitment to maintain the scientific and technical excellence of the activities that have had such an important effect on the Nation and the world.

Thank you very much, Mr. Chairman.

[The prepared statement, plus answers to questions asked of Dr. Edelson, follows:]

Statement
of

Dr. Burton I. Edelson
Associate Administrator for
Space Science and Applications

National Aeronautics and Space Administration

before the

Subcommittee on Space Science and Applications

Mr. Chairman and Members of the Subcommittee:

I am very pleased to be here today to review the Space Science and Applications program with you and to discuss our proposed budget for FY 1984. I know how strongly you have supported the program in the past, and I can assure you that the activities I will discuss today continue the tradition of achievement that has already produced so much new knowledge and technology, so many applications of new technology to national needs, and so much national pride in our space accomplishments.

The Space Science and Applications program has a wide and diverse responsibility, for we seek to understand both the world on which we live and the larger environment in which that world exists. We study the entire Universe with its perspective of immense distances and time scales. We study our cosmic neighborhood, the solar system. We study the more immediate concerns of Earth, such as atmospheric ozone, weather, climate, earthquakes, ocean currents, sea ice motions, and natural resources. We also work to identify and solve problems involving the health and effectiveness of our astronauts in space. All of these studies are connected and reinforced by common themes: to push out the frontiers of scientific exploration, to expand existing knowledge and to seek new knowledge, to understand the Earth as a single planet among many different worlds, and to use the new vantage point from space to study the problems of the Earth and to help solve them.

HIGHLIGHTS OF THE PAST YEAR

The strengths of the Space Science and Applications Program are best illustrated by our accomplishments. Before discussing the budget, I would like to review a few of our many achievements over the past year. Accomplishments such as these, in the final analysis, are the real justification for the Science and Applications program.

Landsat-4. We entered a new era of remote sensing of the Earth with the successful launch of Landsat-4 on July 16, 1982. In addition to the 4-band Multispectral Scanner (MSS) flown on earlier Landsats, Landsat-4 also carries the new 7-band Thematic Mapper (TM). This instrument provides much improved spectral data and better ground details than does the MSS. The quality of the TM images has surpassed all expectations and has demonstrated that the improved capabilities of the TM provide very real advantages to its users. For example, a TM image acquired on August 22, 1982, shows the Mississippi River Valley just north of Memphis, Tennessee in a composite picture. The sediment-laden Mississippi follows a sinuous course from north to south, separating the states of Arkansas and Missouri on the west from Kentucky and Tennessee on the east. Individual farms are clearly visible on both sides of the river, and their boundaries are much sharper than in earlier MSS pictures. Preliminary studies of this image have already indicated that the increased sharpness and greater spectral detail will make TM images much better than earlier MSS images for such uses as input data for crop yield predictions and early recognition of crop stress caused by drought or disease. TM images will make possible more accurate studies of these factors, using fewer images than would be possible with the MSS data alone.

The Landsat TM images can also provide better information about bedrock geology and mineral resources. An image acquired on November 17, 1982 over southern California and Nevada clearly shows Death Valley as a series of whitish interconnected saltpans that trend from northwest to southeast across the scene. Variations in the mineral content of the rocks exposed in the mountains bounding Death Valley produce marked color differences in this image. In many cases, the composition of gravels in the alluvial fan deposits below the mountains can be inferred directly by comparing the colors of the fans to the colors of the source rocks at higher elevations. Major earth structural features are also visible; the linear trace of the Garlock Fault cuts across the lower left corner of the scene, and a series of northwest-trending faults can be seen at the upper left. This TM image even shows a small amount of human impact on this remote and inhospitable environment. The black dots at the upper right are circular irrigation plots that have been artificially constructed and maintained in this extremely arid environment.

Data from approximately 4,000 TM scenes of the continental U.S. have already been acquired and archived during the first six months of Landsat-4 operations; these data are now being processed into pictures. Several research programs are now underway to evaluate in detail the quality and scientific utility of the Landsat-4 imagery. In addition, several foreign governments have decided to upgrade their ground stations to receive TM data, and other countries are actively considering such upgrading.

The NASA Landsat system has been declared fully operational and is being transferred to the National Oceanic and Atmospheric Administration (NOAA). On January 31, 1983, NOAA assumed complete responsibility for operations of the spacecraft, the MSS, and the ground-based MSS Data Processing System. NASA will continue to be responsible for the TM R&D operations and data processing until January, 1985.

Launch of IRAS. On January 25, 1983, we saw the successful launch of the Infrared Astronomical Satellite (IRAS) and the opening of a new window on the universe. IRAS will give us our first detailed views of a multitude of cool and cold cosmic objects --- dust clouds, newly-born stars, and the cores of galaxies --- that emit the bulk of their radiation in the infrared, at wavelengths longer than that of visible light.

By providing this new view of the Universe, IRAS should revolutionize astronomy in the same way that the first ultraviolet and X-ray satellites did during the last two decades. With IRAS, we can finally penetrate the veils of dust that hide much of our galaxy and observe its core. We can measure how much starlight is absorbed by interstellar dust, and we can study small nebulas, dust clouds, and young stars in order to obtain new and fundamental information about how stars and planets form.

IRAS represents a significant technological accomplishment as well as an important scientific achievement. The instruments on IRAS involve many ambitious designs, and many problems were successfully solved during their development and construction. For instance, the infrared telescope itself is surrounded and cooled by superfluid liquid helium to no more than two degrees above absolute zero, and the detectors used were developed only after the project had begun.

The IRAS spacecraft is now fully operational and is already returning scientific data. A minor problem with one of the sun sensors has already been solved by changing the software, and the control system is now operating normally. The telescope cover was removed on January 31, and the telescope has proven to be even more sensitive to the infrared wavelengths than we had expected. A "mini-survey" of infrared sources along the plane of our galaxy has already been completed, and we have just begun the full-sky survey for which IRAS was planned. We now estimate that the number of individual infrared sources observed by IRAS during its lifetime will approach 100,000.

Even though the first scientific results are just coming in, there is already tremendous excitement about the data and the surprising things that they show about the universe. All the problems and difficulties that we have surmounted in building and launching IRAS are about to be repaid with a real harvest of important and exciting scientific knowledge.

IRAS is the result of a major cooperative effort involving the Netherlands, the United Kingdom, and the United States --- each making a significant contribution to this challenging and technically complex mission.

Shuttle Imaging Radar (SIR-A). Shuttle-based remote sensing of the Earth has also made major strides during the last year as scientists have analyzed, in detail, the results from six experiments on the OSTA-1 payload, which was carried into Earth orbit by the STS-2 flight in November, 1981. The results have already established the ability of Shuttle-based radar, infrared, and visible-light observations of the Earth's surface to provide critical environmental data---the chlorophyll content of the oceans, the carbon monoxide content of the atmosphere, and the locations of economically significant minerals.

Data collected by the Shuttle Imaging Radar (SIR-A) proved to be especially important for mapping the geological structure of the Earth. This instrument was able to penetrate surface vegetation and to identify geological folds, faults, and lineaments that could not be observed from the surface of the Earth. An especially exciting and unexpected result was the ability of SIR-A to penetrate thick layers of windblown sand in desert regions and to reveal the bedrock structure underneath. SIR-A imagery of the eastern Sahara Desert, for example, has revealed subsurface stream channels that cannot be observed with Landsat imagery or from the ground. The channels, which seem to be between 10 and 50 million years old, have been linked to an ancestral River Nile. This discovery provides important new insights into the geological history, archeology, and human history of this region.

Search and Rescue Satellite (SARSAT) Success. The cooperative COSPAS/SARSAT Project between the United States, Canada, France, and the Soviet Union, which uses satellites to detect and locate aircraft and ships in distress, has already been credited with saving lives. On June 30, 1982, the Soviet Union launched COSPAS I, the first satellite in this joint project, and on September 1, all four nations began a period of system checkout. The effectiveness of the system was dramatically demonstrated almost immediately when a small aircraft which had crashed in a remote region in northern British Columbia was detected by using the COSPAS/SARSAT system. The seriously injured pilot and two passengers were quickly rescued. By mid-November, the new system had saved ten lives in both aircraft and marine accidents. The first U.S. SARSAT-equipped satellite, NOAA-E, is scheduled to be launched in March, 1983. This launch will complete the preliminary two-satellite network needed to test the complete SARSAT system. Norway and the United Kingdom have recently joined the project.

BUDGET REQUEST

The total FY 1984 Research and Development request for the Office of Space Science and Applications is $1068.0 million.

I believe that the budget I am going to present reflects a vital and stimulating program in Space Science and Applications. This budget supports conclusion of the Landsat-D program, with the D' spacecraft being completed in FY 1983 and the Thematic Mapper ground system development being completed in FY 1984. This budget request also supports Space Telescope development efforts; continues development of efforts on the Galileo Jupiter mission leading to a Shuttle/Centaur launch in 1986; continues International Solar Polar Mission experiment development for launch on a Shuttle/Centaur in 1986; continues the development efforts on the Gamma Ray Observatory (GRO) for launch in 1988; and continues a broad spectrum of activities in Spacelab payload development and mission management, basic research, and data analysis activities.

Important new or expanded activities in three program areas are also included in this request. First, the Venus Radar Mapper (VRM) mission, which will map the entire surface of Venus, is a key element in the revitalization of our Planetary Exploration program. Second, funding for the Advanced Communications Technology Satellite (ACTS) project will permit development of new communications technology which is needed to maintain U.S. leadership in this important field. Third, an increase over the FY 1983 Explorer Program level is being requested to maintain NASA's ability to develop low-cost, scientifically valuable flight missions in space astronomy. The increased FY 1984 funds will permit us to initiate development efforts on the Extreme Ultraviolet Explorer (EUVE) and to expedite other Explorers now under study or development.

The details of the FY 1984 Space Science and Applications budget request are displayed in Charts #1 and #2. I will now briefly review the content of each of these major elements.

Solid Earth Observations. The requested FY 1984 funding will allow the Landsat-D Thematic Mapper ground system development to be completed. The Shuttle/Spacelab Payloads funding will support a 1984 flight of the Large Format Camera along with an improved version of the successful Shuttle Imaging Radar program. Development of advanced techniques for land remote sensing will also be continued as a part of the Shuttle/Spacelab payload activities. The Geodynamics program funding is required for continuation of efforts to improve our understanding of the dynamic processes that occur at and beneath the surface of the Earth. The NASA portion of the AgRISTARS program will be phased out in FY 1983. The appropriate user agencies will continue to support AgRISTARS activities in FY

1984. The Research and Analysis activities will be continued in FY 1984 to conduct definition studies for potential new remote sensing capabilities and to continue to encourage the utilization of Landsat-type technologies by government and industry.

Environmental Observations. The requested funding for the Upper Atmospheric Research Program will allow us to continue to improve our understanding of the upper atmosphere. A major part of this effort, the Upper Atmosphere Research Satellite (UARS) experiment design and development activities, will be continued in FY 1984. We are continuing to look at ways to reduce the cost of the UARS mission. In addition to upper atmosphere studies, related Research and Analysis activities will be continued in the areas of ocean science, plasma physics, global weather and climate, and radiation and global dynamics.

Shuttle/Spacelab Payloads development funding will support analysis of data from environment-sensing instrumentation on the OSTA-2 Shuttle payload and will also support completion and calibration of the Atmosphere Trace Molecules Observed by Spectroscopy (ATMOS) instrument for future Shuttle flights. NASA and DOD will proceed jointly to develop the Combined Release and Radiation Effects Satellite (CRRES) mission. NASA's portion of the mission will consist of development of a chemical release experiment which will use various chemicals as tracers in the ionosphere and magnetosphere. The DOD portion of the mission will consist of a study of the effects of the space radiation environment on a new generation of integrated circuits.

The Earth Radiation Budget Experiment (ERBE) activities are continuing in preparation for launch on a NOAA spacecraft in 1984 and on the Earth Radiation Budget Satellite (ERBS) in 1984. The actual launch dates for these instruments will be determined by the requirements of NOAA's operational weather satellite system.

Mission operations and data analysis activities in support of the Solar Mesosphere Explorer (SME) and Nimbus-7 missions will be continued in FY 1984. The International Sun-Earth Explorer (ISEE-3) is being shifted into a new series of orbits from which it can observe the distant magnetic tail of the Earth. It will then be shifted into a new orbit to intercept the tail of Comet Giacobini-Zinner in September, 1985, thus providing the first in situ measurements of a comet tail.

Materials Processing in Space. The Materials Processing in Space program will continue its efforts to focus on the use of zero-g environment to develop and process new types of materials. The small decline in the FY 1984 funding request from the FY 1983 level reflects completion of the major hardware development phase. An important event in FY 1983 will be the first flight, on the OSTA-2 payload, of the Materials Experiment Assembly

(MEA), a self-contained package with two furnaces and an acoustic levitator, to perform experiments on crystal growth and transport phenomena, metallurgy, and containerless processing. The commercial viability of producing biomaterials in space will continue to be evaluated in 1983 with additional Shuttle flight experiments of the Continuous Flow Electrophoresis System (CFES). Space Processing Material Experiment Operation activities will concentrate on the analysis of recent Shuttle flight experiments such as the Monodisperse Latex Reactor (MLR) flown in 1982 on STS-3, small-instrument development, and research on potential future flight experiments such as those using a directional solidification furnace. Efforts will also be concentrated on the continuation of ground-based experiments that use the short-duration, low-gravity environment provided by suborbital aircraft and rocket flights, drop towers, and drop tubes.

Communications. A major new effort to develop and test the technology needed to maintain U.S. leadership in space communications, the Advanced Communications Technology Satellite (ACTS) project, will proceed into design and development activities in FY 1984. I will discuss the ACTS program in more detail later. Requested Research and Analysis funding will support the continued development of advanced technology applicable to a wide range of future communications systems. Technical consultation and support studies on world-wide communication problems will be continued at the FY 1983 funding level. We are also holding discussions with Canada about possible cooperation in an experiment to develop satellite communication systems for mobile vehicles. Experiment coordination and operation support will also be continued in FY 1984 on the Advanced Technology Satellites ATS-1, -3, and -5.

Physics and Astronomy. Within this program, the Space Telescope (ST) Observatory remains the centerpiece of our on-going efforts. Last year, we completed the primary mirror and demonstrated that its figure quality exceeded specifications. We have begun the delicate task of mounting the various support brackets to the back side of the primary mirror, being careful not to introduce any distortions into the mirror itself.

As might be expected in a program of this complexity, we are experiencing certain difficulties particularly in the development of the Optical Telescope Assembly and the fine guidance sensors. The effort required to assemble this telescope is turning out to be larger than we had anticipated. We are reviewing a range of actions which address the technical, cost and schedule issues confronting the project. As our evaluation of these issues progresses, we will keep the committee informed of the status of the program and of any actions taken.

Significant progress is also being made in other areas of the ST project. The first of five scientific instruments for ST was delivered to NASA in July 1982; we expect deliveries of the remaining four to be made during the spring and summer of 1983. Work on the Support Systems Module is progressing on schedule. The critical design review was successfully completed in March, 1982, and fabrication of all major elements is now underway.

In a few months, we will open the new Space Telescope Science Institute which has been established at the Johns Hopkins University. We are having success in assembling a quality staff who are working on the computer software for carrying out scientific investigations with this space observatory. The Space Telescope remains our most significant opportunity to advance scientific knowledge and permit us to retain our world leadership in astronomy.

The Gamma Ray Observatory (GRO) design and development activities will be continued in FY 1984, leading to a launch in 1988. GRO will enable us, for the first time, to survey systematically the highest energy radiation produced by such violent and puzzling objects as pulsars, quasars, black holes, and supernova explosions. Germany and the Netherlands are participating in instrument development, and the United Kingdom will participate in data analysis.

In the Shuttle/Spacelab Development and Mission Management area, requested FY 1984 funds will support the development of Physics and Astronomy instruments and will also provide for mission management activities required to support all NASA Spacelab payloads. The increased FY 1984 funding request is slightly higher than the FY 1983 level, which reflects the fact that, with the first flights of the STS having been successfully completed, we are now planning to substantially build up our Shuttle/Spacelab Payloads program. During FY 1983, we will launch the first Spacelab mission, carrying a multi-disciplinary science payload in a joint effort between the U.S. and the European Space Agency (ESA). We have also undertaken an ultraviolet astronomy mission, named Astro (formerly OSS-3/7) which will fly for the first time in 1986 to observe Halley's comet. Another important project now in development is the Solar Optical Telescope (SOT), a 1.2-meter solar telescope that will permit new ultra-high-resolution studies of the Sun in a range of wavelengths --- near infrared, visible, and ultraviolet.

FY 1984 Explorer Development funding will provide for completion of development activities on the Active Magnetospheric Particle Tracer Explorers (AMPTE), a cooperative project with Germany to study how charged solar wind particles enter the Earth's magnetosphere. AMPTE is scheduled to be launched in

1984. The requested Explorer Development funding will also support continued development activities on the Cosmic Background Explorer (COBE), leading to a planned launch in 1989. The FY 1984 budget request will also provide for initiation of design and development activities on the Extreme Ultraviolet Explorer (EUVE), which will survey the universe at radiation wavelengths between the X-ray and ultraviolet regions. This region will be (after the launch of GRO) virtually the last unexplored portion of the electromagnetic spectrum. EUVE is expected to provide new information on hot objects and to enhance our knowledge of the final stages of the evolution of stars.

The FY 1984 Physics and Astronomy Mission Operations and Data Analysis (MO&DA) budget request reflects an increase over the FY 1983 level. This increase is largely due to the required buildup in support activities in preparation for operation of the Space Telescope and to obtain inventory hardware items that will be needed for its subsequent maintenance and refurbishment. In addition, the MO&DA funds will support continued operation and data analysis activities for the International Ultraviolet Explorer (IUE), retrieval/repair activities on the Solar Maximum Mission (SMM) spacecraft and experiments, for the High Energy Astrophysical Observatory (HEAO) data analysis, and operation of such other Explorer spacecraft as the Infrared Astronomical Satellite (IRAS).

Research and Analysis funding is also required in FY 1984 to continue fundamental scientific research in many areas, as well as the conceptual development of possible future missions, development of new technology required to support these missions, and analysis of data from past missions.

In our Physics and Astronomy suborbital program -- which includes sounding rockets, aircraft flights, and balloon flights -- we will be able to support over 50 sounding rocket flights, approximately 65 flights of the Kuiper Airborne Observatory aircraft, and approximately 50 balloon flights in FY 1984. Additionally, funding for the airborne instrumentation research is included within the FY 1984 suborbital budget request. These research aircraft will continue to be utilized in support of multidisciplinary science and applications research activities such as the collection of cosmic dust particles and the sampling of volcanic dust from the 1982 eruption of the El Chichon Volcano in Mexico.

Planetary Exploration. As part of the revitalization of the Planetary program, a program which has brought so much new knowledge and prestige to the nation, we are requesting FY 1984 funds for initiation of design and development actitivies on the Venus Radar Mapper (VRM) mission to obtain global maps of the cloud-hidden surface of Venus. The VRM mission is a lower-cost and less complex Venus mapping project than the previously

planned Venus Orbiting Imaging Radar (VOIR) mission, but it still retains the major radar mapping objectives of the earlier mission. I will discuss the VRM mission in more detail later.

The Galileo mission development activities continue to proceed toward a 1986 launch on the Shuttle/Centaur Upper Stage combination. The FY 1984 funding for Galileo includes $13 million to reimburse the Department of Energy (DOE) for development activities on the Radioisotope Thermoelectric Generators (RTGs). The change of the launch vehicle from an Inertial Upper Stage (IUS) to the Centaur necessitated slipping the launch from 1985 to 1986; however, by using the more powerful Centaur, we will actually arrive at Jupiter in late 1988 instead of in early 1990.

The requested FY 1984 funding for the International Solar Polar Mission (ISPM) will support continuation of development activities on the U.S. experiments which will be flown on the single European spacecraft mission. In addition, the U.S. will provide launch and tracking support to the ISPM. The ISPM spacecraft will be launched on a Shuttle/Centaur combination in 1986.

The FY 1984 Planetary Mission Operations and Data Analysis funds will support continuation of activities leading to the Galileo and ISPM launches in 1986, continuation of operations and data analysis activities in support of the Pioneer Venus Orbiter and Pioneers 6 through 11, and continuation of Voyager operations leading to an encounter with Uranus by Voyager 2 in 1986.

Research and Analysis funding will support continuation of the Infrared Telescope Facility and Lunar Curatorial Facility operations. A wide range of basic planetary research projects will be continued in 1984, including support of several U.S. co-investigators who are working on the European Giotto mission to study Comet Halley, and our coordinating efforts in the International Halley Watch.

Life Sciences. The FY 1984 Life Sciences Research and Analysis Program will continue to support ground-based basic research in such areas as space-related biomedical phenomena, gravitational physiology, life-support systems, and the origin of life in the universe. A slight increase over the FY 1983 level is requested to enhance investigations of the space adaptation syndrome and to develop potential countermeasures for this problem.

The FY 1984 funding for Life Sciences' Flight Experiments will be used to continue development of Spacelab instrumentation to promote a better understanding of the effects of weightlessness on humans and other living things. In particular, these funds will support the continued development of payloads to

be flown on Spacelab 4, which is scheduled for launch in 1985. This will be the first dedicated Life Sciences Spacelab mission, and we hope it will be a key step forward in understanding the physiological changes produced in humans by space flight.

Spacelab Flight. The development of integrated scientific payloads for Spacelabs carried in the Space Shuttle has become an increasingly important part of our current activities in the Shuttle era. Although some individual scientific instruments have already flown on the Shuttle, we plan to launch the most ambitious scientific Shuttle payload to date -- Spacelab 1 -- in 1983. This cooperative mission between NASA and the European Space Agency (ESA) will use the ESA-built Spacelab system to carry out 71 investigations developed by U.S. and European scientists on astronomy, solar physics, plasma physics, atmospheric physics, Earth observations, life sciences, and materials sciences. Later missions, which are in various stages of development, include Spacelab 2, which will carry experiments in astronomy and related sciences, and Spacelab 3, which will carry experiments in materials processing, life sciences, and advanced technology.

I now want to discuss in more detail two items in the budget that represent major new undertakings in FY 1984 --- the Venus Radar Mapper (VRM) mission and the Advanced Communications Technology Satellite (ACTS) project.

Venus Radar Mapper (VRM) Mission. We are requesting $29 million in FY 1984 to initiate the Venus Radar Mapper (VRM) mission, which will obtain detailed radar maps of the cloud-covered surface of Venus. These maps are essential for geological studies of Venus' surface and interior, just as other surface maps have been essential for exploring and understanding the other terrestrial bodies -- Mercury, Mars, the Moon, and the Earth. The VRM mission, which will be launched in 1988 by the Shuttle/Centaur upper stage combination, will use a synthetic aperture radar (SAR) to penetrate the thick clouds that always cover Venus. The recent Seasat and SIR-A projects have successfully demonstrated the SAR imaging technique from Earth orbit and have shown that such radar images can be used for morphological and geological studies.

The VRM mission will image virtually all of the surface of Venus, an area three times as great as the entire land area of the Earth, producing maps with resolutions more than 10 times better than we can obtain from Earth-based radars or from the Pioneer Venus spacecraft. Currently available maps of Venus are adequate to show only large-scale geological provinces, and this higher resolution is needed to see smaller features like volcanoes, impact craters, lava flows, tectonic faults, fluvial erosion channels, and possible remnant oceanic shorelines. It is necessary to identify and study these small-scale features on

Venus in order to understand the history of Venus and to learn why the Earth and Venus, which are so similar in many ways, have followed evolutionary courses which are so obviously different.

In order to achieve these scientific objectives at a relatively low cost, VRM will make use of spare hardware from the Voyager, ISPM, and Galileo projects. The mission plan also assumes a simplified method of operating the spacecraft to minimize costs during the one-year mission operations period. The VRM project will be managed by the Jet Propulsion Laboratory.

Advanced Communications Technology Satellite (ACTS) Payload. NASA has defined and structured an ACTS payload to emphasize the high-risk technology development required to assure continued U.S. preeminence in the field of satellite communications. The objectives of ACTS are to prove the feasibility of the technology required to alleviate orbit and radio spectrum saturation and to enable continued cost-effective growth in the capacity of communications satellite systems. Critical technology being developed includes the multibeam antennas and associated onboard switching components needed to reuse the frequency spectrum. These technologies have been under development by U.S. industries for the past three years, and they will be usable in multiple frequency bands applicable to a wide range of future communications systems required by NASA, other U.S. government agencies, and industry. In order to establish the feasibility and validity of these technologies, we will develop an experimental satellite payload to be launched into Earth orbit in 1988. Extensive industry involvement is anticipated, including industry cost-sharing. The ACTS project will be managed by the Lewis Research Center.

SUPPORTING PROGRAMS

The Supporting Programs in the various disciplines provide an indispensable foundation for all science, applications, and exploration activities. The research and analysis activities include a variety of essential activities such as ground-based observations, laboratory experiments and analyses, theoretical studies, extended mission data analysis, and instrument definition and development. The suborbital programs allow flight testing of new instrumentation as well as the conduct of scientific programs requiring measurements at heights below satellite altitudes. These programs generate the critical scientific base for space missions, provide scientific data not otherwise obtainable, and help obtain an understanding of the observations that we make in space.

To illustrate the important role of these supporting activities, I will mention a few highlights and then describe some scientific and technical accomplishments during the past year. During FY 1982, in the active program of suborbital

research activities, one important project involved the simultaneous launch of four different balloons in September, 1982 to intercompare the stratospheric data collected by thirteen different instrument payloads provided by seven nations.

In the area of aircraft-supported research, we are about to undertake a special project in collaboration with the Australian government, during which we will make 15 flights of the Kuiper Airborne Observatory (KAO) in the southern hemisphere. These flights will carry out some of the first detailed investigations of infrared-emitting objects near the center of our galaxy and will also observe an extremely rare occultation of a bright star by the planet Neptune. The latter observation will be our first good opportunity to discover whether Neptune has rings.

Our Research and Analysis activities produced a number of important scientific discoveries last year. Astrophysical investigators made the first optical identification of a gamma-ray burst source. A large burst on November 19, 1978, which was detected by instruments on several different spacecraft, was found to match the location of an optical flash recorded on a photographic plate taken in 1928. It is not clear whether gamma rays were also emitted in 1928, but the behavior of this object over the last 50 years challenges our current theories for the origin of such gamma-ray bursts. Major results in the planetary sciences included the detection of Comet Halley, still beyond the orbit of Saturn, as it approaches the sun for its 1985-1986 appearance; the discovery of six new Earth-crossing asteroids, bringing the total number now known to 51; and evidence that at least four satellites of Uranus are covered with water ice, while Triton, the largest satellite of Neptune, has a surface of frozen methane. In addition, more than 375 new meteorite samples were recovered from the Antarctic, one of which may be from the Moon; recent studies of other Antarctic meteorites have provided strong evidence that they came from Mars. Fragments of unusual granite have been found in some lunar rocks, indicating a more extensive early chemical development of the Moon than was previously thought.

Our supporting programs also continue to be the source of technical developments which support future science activities in a cost-effective manner. A major achievement in FY 1982 was the successful reeling down and return of an atmospheric instrument to a point 15 kilometers below a balloon that was itself 40 kilometers above the Earth. This technique is likely to become increasingly important for atmospheric studies. In addition, as part of our sounding rocket program, we are developing three "Spartan" vehicles which will carry small instruments, of the type used in sounding rocket payloads, on the Space Shuttle. These vehicles and their instruments will be released in orbit and subsequently recaptured, thus increasing the available

observing time in space from the few minutes available in a rocket flight to nearly two days. The flight of Spartan 1 is scheduled for 1984.

These supporting activities are essential to the future of our exploration of space. In addition to the scientific results they produce, these programs also engage a highly-skilled and active community of space scientists. These scientists interpret the discoveries on our space missions, provide essential advice about our programs, and train younger scientists who will make the discoveries of the future. Strong supporting programs continue to be an essential investment for our future success.

FUTURE DIRECTIONS

We have developed a strategy to construct a Space Science and Applications program that is balanced, both in terms of the various scientific disciplines we support --- astrophysics, planetary sciences, Earth sciences, and life sciences --- and in terms of the balance of large and small missions.

Because of the long time (often several years) needed to define a new mission, we are continuing to study actively a number of possible future missions. In physics and astronomy, our astrophysics planning is fully consonant with the recently published report of the National Academy of Sciences Astronomy Survey Committee, Astronomy and Astrophysics for the 1980s. This report encompasses the recommendations of the U.S. Space community for both ground- and space-based astronomy. The Advanced X-ray Astrophysics Facility (AXAF) is the top priority major new program recommended for all astronomy in this report. We are continuing our studies to define AXAF so that astronomers will have the higher resolution x-ray observations needed to understand the details of such changing and violent objects as quasars, black holes, and the centers of galaxies.

In FY 1984 we will also initiate definition studies on the highly recommended Shuttle Infrared Telescope Facility (SIRTF). This will be a Shuttle-attached 1-meter-diameter, cryogenically-cooled telescope to follow up IRAS observations and to examine, in detail, the cool regions of dust clouds, protostellar systems, and the cores of other galaxies.

The Astronomy Survey Committee also recommended several new Explorer missions which we are studying, including the X-Ray Timing Explorer (XTE) and the Far Ultraviolet Spectroscopy Explorer (FUSE). A number of other candidate projects are also being considered for more detailed study.

In planetary science, the future of solar system exploration has been extensively studied during the past two years by the Solar System Exploration Committee (SSEC), an advisory group

charged with recommending how future exploration of the solar system should be carried out. The SSEC, after completing the first phase of their deliberations, has concluded that the principal goal of the planetary program should remain one of scientific exploration aimed at understanding the nature, origin, and evolution of the solar system. Because it is crucial to try and reduce the cost of individual missions, the committee has recommended several low-cost but scientifically important future missions to form a core program of planetary exploration. Some candidate missions include a Mars geochemistry/climatology orbiter, a rendezvous with a comet, and a probe mission to enter Titan's atmosphere. The first part of the SSEC's report and recommendations will be completed early in 1983.

In Earth sciences, we are also continuing to study several possible future missions to determine better the global characteristics of the Earth as a planet and the coupling between the Earth and the Sun in the environment of space. In planning these activities, we pay careful attention to the advice given by such scientific groups as the National Academy of Sciences' Space Science Board's Committee on Earth Sciences in their report A Strategy for Earth Science from Space in the 1980s as well as to the deliberations of the Academy's Committee on Solar and Space Physics. We are continuing to study different mission concepts to try to identify a lower cost Upper Atmosphere Research Satellite (UARS) mission than is presently identified. The UARS mission is needed to make global measurements of the chemistry, dynamics, and energy transfer in the upper atmosphere, which is a vital link in the Earth's environmental system. These measurements are essential if we are to understand this region and to predict the effect of human activities on such features as the stratospheric ozone layer. Another potential future mission, the Ocean Topography Experiment (TOPEX), is required to determine accurately the elevation of the ocean surface on a worldwide basis, thus providing detailed measurements of ocean currents and other aspects of ocean dynamics. We will also continue to study a four-spacecraft mission called the Origin of Plasmas in the Earth's Neighborhood (OPEN), which will make detailed and systematic measurements of the charged particle radiation and the magnetic and electrical forces that act to transfer, store, and dissipate energy in space near the Earth. Another potential mission, the Geopotential Research Mission (GRM) may provide a tenfold improvement in the accuracy and resolution with which the Earth's gravity and magnetic fields can be measured, thus allowing us to better understand the dynamic forces beneath the Earth's surface.

Conclusion

As I noted in the beginning, the Space Science and Applications program has established a long tradition of achievement. We have made great strides in understanding the universe and in learning about the Earth as a planet. The FY 1984 budget represents a commitment to maintain the momentum in scientific and technical excellence that has had such an important impact on the nation and the world, to continue the outstanding effort of the past, to initiate new activities, and assure the preservation of the scientific research base that is critical to U.S. leadership in space.

Questions submitted by Chairman Volkmer during the February 22, 1983 hearing.

QUESTION E-1:

Apart from the satellite communications area, which has been a commercial success now for nearly two decades, can you describe for us:

What are the character and magnitude of the economic returns we have received (for instance, new employment, increased tax base, increased international trade...) that should encourage us to continue to fund such Space Applications undertakings? Please give specific examples.

ANSWER E-1:

Encouragement to continue funding research for potential Space Applications can be gained from reviewing some of the economic returns this nation has received from past space ventures.

In the field of remote sensing, there are many specific examples of improved information and operating efficiencies which have accrued through the use of satellite data--especially in conjunction with conventional data. For example, in addition to NOAA's use of satellite data for meteorology, the Foreign Agricultural Service of the U.S. Department of Agriculture has implemented an operational system to forecast the harvest of certain large area crops (such as wheat) which are important in international commodity trading. The Department of the Interior routinely uses remotely sensed data in natural resources, water resources, habitat, and rangeland management studies. In industry, Weyerhauser Corporation has developed a forest information system which incorporates satellite data with conventional data. Petroleum and mineral exploration companies routinely use satellite data to their advantage.

The applications work we have done in the last several years, exclusive of the satellite communications areas, has not been aimed at a specific industry from which we could collect the statistics. For example, in the Materials Processing program which is still in its infancy, we are attempting to provide a scientific underpinning. Therefore, any general projections of economic return would be highly speculative. The projections of economic return in the McDonnel Douglas/Johnson and Johnson joint endeavor agreement are proprietary to the companies involved.

In remote sensing for meteorology, the utilization of data is so extraordinarily broad that we have no firm track at this time to estimate economic return from performance in those areas. NOAA and others have repeatedly tried to work out what the economic return from satellite meteorology might be, the benefits are spread so broadly and through so many avenues that it is almost impossible to put together a credible analysis of the economic return of meteorological services--despite the fact that there is general agreement that those services are extremely important to the general economy.

The situation is similar in land remote sensing. We have been working regularly with the Department of Agriculture to improve the efficiency of crop forecasting and other activities which in the long run will result in benefits for U.S. agricultural interests. Yet, neither NASA nor USDA have developed the ability to determine, in an accounting sense, what contribution was made by remote sensing.

In the long run, we are convinced that there is very substantial overall economic gain to the United States economy from the applications activities we have undertaken; but we have not found a way to make a firm statement on the magnitude of that return. Most importantly, the land remote sensing applications are in their earliest stages of utilization, and detailed information on economic returns is not available at this time.

QUESTION E-2:

In view of NASA's past dozen years of study and experience in the space applications area, what returns of economic value can we expect from the additional investments in Space Applications -- not space science or basic research -- for which you are seeking funding this year? Please give specific examples.

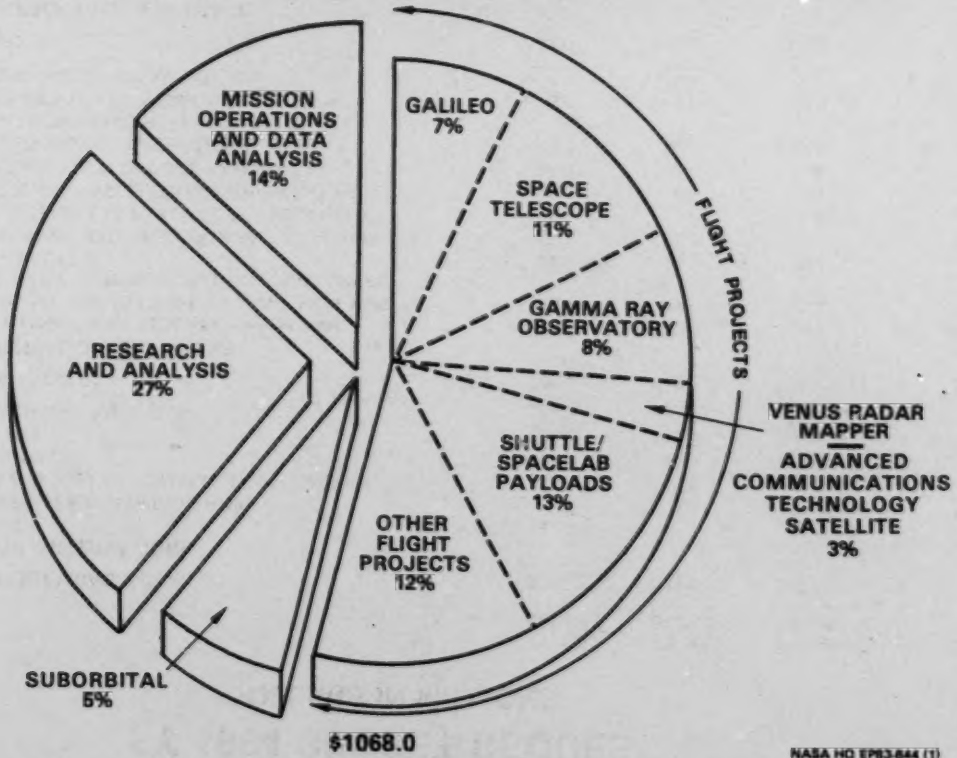
ANSWER E-2:

The United States is a global trading nation and conditions elsewhere in the world have important effects on the U.S. economy. Therefore, the United States, both government and industry, requires accurate, timely global information. Over the years, the U.S. economy can be expected to benefit significantly from the now emerging capabilities to acquire and assimilate such global information. The problem is that we do not have a means to accurately make firm estimates of the marginal economic advantage of having information provided by remote sensing systems. The applications research, which we are continuing, is expected to provide improved capabilities in meteorology, oceanography, and land remote sensing. Much of this work will result in improving performance of government functions. For instance, efforts to improve interpretative abilities using Landsat data will be of substantial value to the Department of the Interior in rangeland and wetlands management, the Department of Agriculture in land use classification and crop forecasting, and NOAA in improved forecasting. To the extent that the activities of those agencies are important to the general economic well being of the country, there will be a payback as a result of that government effort.

QUESTION E-3:

Why, now, under the general title of Space Science and Applications, do the funds being requested for Space Applications appear to be such a small fraction of this total? Why does the market-related technology transfer activity, heretofore considered vital to the translation of new knowledge and technology to extensive actual public and private use, no longer seem to command explicit attention?

OFFICE OF SPACE SCIENCE AND APPLICATIONS
RESEARCH AND DEVELOPMENT BUDGET — FY 1984
(DOLLARS IN MILLIONS)



(Fig. 1)

OFFICE OF SPACE SCIENCE AND APPLICATIONS
FY 1984 BUDGET REQUEST
(DOLLARS IN MILLIONS)

	FY 1982 BUDGET	FY 1983 BUDGET	FY 1984 REQUEST
SPACE APPLICATIONS TOTAL	324.2	351.0	289.0
SOLID EARTH OBSERVATIONS			
LANDSAT-D	81.9	61.7	15.8
EXTENDED MISSION OPERATIONS	2.8	1.8	1.0
SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT	12.3	13.8	15.0
GEODYNAMICS	22.9	26.2	28.0
AgRISTARS	14.0	15.0	—
RESEARCH AND ANALYSIS	15.5	13.7	14.6
SUBTOTAL	149.4	132.2	74.4
ENVIRONMENTAL OBSERVATIONS			
UPPER ATMOSPHERE RESEARCH PROGRAM	20.5	27.7	29.6
OCEANIC PROCESSES RESEARCH AND ANALYSIS	16.9	17.0	18.2
ATMOSPHERIC DYNAMICS/RADIATION RESEARCH AND ANALYSIS	22.3	26.5	28.4
SPACE PLASMA/ATD RESEARCH AND ANALYSIS	12.1	15.2	15.7
SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT	4.1	3.7	7.6
OPERATIONAL SATELLITE IMPROVEMENT PROGRAM	6.0	6.0	0.6
EARTH RADIATION BUDGET EXPERIMENT	24.0	24.0	15.5
EXTENDED MISSION OPERATIONS	16.1	22.8	27.4
UPPER ATMOSPHERIC RESEARCH SATELLITE EXPERIMENTS AND MISSION DEFINITION	6.0	14.0	20.0
HALOGEN OCCULTATION EXPERIMENT	5.0	—	—
SUBTOTAL	133.0	156.9	163.0
MATERIALS PROCESSING IN SPACE			
RESEARCH AND ANALYSIS	12.0	13.1	14.0
MATERIALS EXPERIMENT OPERATIONS	4.2	8.9	7.6
SUBTOTAL	16.2	22.0	21.6

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(Fig. 2)

OFFICE OF SPACE SCIENCE AND APPLICATIONS
FY 1984 BUDGET REQUEST (CONTINUED)
(DOLLARS IN MILLIONS)

	FY 1982 BUDGET	FY 1983 BUDGET	FY 1984 REQUEST
COMMUNICATIONS			
RESEARCH AND ANALYSIS	15.4	5.1	8.5
SEARCH AND RESCUE	2.3	3.7	3.8
TECHNICAL CONSULTATION AND SUPPORT	2.6	2.6	2.7
EXPERIMENT COORDINATION AND OPER. SUPPORT	1.0	1.0	1.1
ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE	—	20.0	5.0
SUBTOTAL	21.3	32.4	21.1
INFORMATION SYSTEMS	4.3	7.5	8.9
PHYSICS AND ASTRONOMY-TOTAL	322.5	441.0	514.6
SPACE TELESCOPE DEVELOPMENT	121.5	137.5	120.6
GAMMA RAY OBSERVATORY DEVELOPMENT	8.0	34.5	89.8
SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT AND MISSION MANAGEMENT	47.6	83.0	92.9
EXPLORER DEVELOPMENT	33.3	34.3	48.7
MISSION OPERATIONS AND DATA ANALYSIS	45.3	74.8	79.5
RESEARCH AND ANALYSIS	22.9	28.8	29.8
SUBORBITAL PROGRAMS	43.9	48.1	53.3
PLANETARY EXPLORATION-TOTAL	210.0	186.4	205.4
GALILEO DEVELOPMENT	115.7	91.6	79.5
INTERNATIONAL SOLAR POLAR MISSION DEV.	5.0	6.0	8.0
MISSION OPERATIONS AND DATA ANALYSIS	42.6	38.5	43.4
RESEARCH AND ANALYSIS	46.7	50.3	45.5
VENUS RADAR MAPPER	—	—	29.0
LIFE SCIENCES-TOTAL	39.5	55.7	59.0
SHUTTLE/SPACELAB PAYLOAD DEVELOPMENT	14.0	24.0	23.0
RESEARCH AND ANALYSIS	25.5	31.7	36.0
TOTAL OFFICE OF SPACE SCIENCE AND APPLICATIONS	896.2	1034.1	1068.0

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1-6-83

(Fig. 3)

ANSWER E-3:

Over the last several years, the Space Applications program has been about half the size of the Space Science Program. For FY 84, the budget for Space Applications reflects the completion of a major element of Space Applications work, that is, the completion of Landsat-4 and D prime, and the transfer of their operating responsibility to NOAA. The market related technology transfer activity has also been reduced because NASA's Landsat research is now largely focused on the Thematic Mapper for which applications techniques are just emerging and in the expectation that private industry would assume its appropriate role.

QUESTION E-4:

If NASA cannot enumerate specific economic payoffs commensurate with the great sums invested, then could it explain why its Space Applications program should be continued? And how could this be explained to the public?

ANSWER E-4:

The research efforts that lead to space applications should be continued because R&D conducted by NASA has led to greatly improved capabilities in communication and the acquisition of reliable information on global conditions (e.g., meteorology, geology and mineral prospecting, agriculture, forestry, etc.). Though NASA cannot aggregate cumulative economic payoffs commensurate with the great sums invested, quantitative dollar return is not the sole measure of the payoff from the Space Applications programs. The Search and Rescue (Sarsat) program is an example of an acknowledged benefit from the Space Applications program effort but cannot be quantified in an accounting sense. Between its inception in September 1982 and February 1983, Sarsat assisted in 11 separate distress incidents which resulted in the saving of 21 lives. Furthermore, part of the reason for conducting the Space Applications program is to improve the productivity and performance of their functions by government agencies. NASA's mission in research and development is to conduct the long-term research to create new capabilities where there may presently be little commercial base. Continued Space Applications research is needed not only to capitalize on recently demonstrated capabilities such as ocean observing systems, but also to realize capabilities just coming into view such as the derivation of elevation maps from analysis for poorly mapped, inaccessible regions. The proper exploitation of those capabilities will take time.

QUESTION E-5:

If NASA expresses the view that it should concentrate on basic research in anticipation that the private sector will be able to apply NASA results without much difficulty or delay, then:

a. How does NASA justify the large and expensive marketing activity in its largest space applications program area -- the Space Shuttle?

The situation in satellite communications is significantly different from the situation in remote sensing, position fixing, and materials processing. Though each of those areas has distinct characteristics, none has proven to have an aggregated, currently profitable industry which could be expected to assume the tasks of final development and marketing of new applications.

QUESTION E-6:

Given these expressed views, can you explain to us how, in the remote sensing area, our purposes now are being served better by a separation of activities which finds one Federal agency, NASA, supporting Applications research and study from space of our planet's physical characteristics while another Federal agency, NOAA, stimulates the marketplace for remote sensing services and prompts our private sector to take up the provision of remote sensing systems and services?

ANSWER E-6:

The U.S. policy, since the mid-1960's, has been that NASA conduct research and development and that NOAA manage the operational weather systems (polar then geosynchronous weather satellites). In the late 1970's this general approach was extended to land remote sensing when it became apparent that Landsat was approaching operational status. Making remote sensing data available for others is a proper function of the manager of an operational system. Landsat is now operational and it is consistent to place the production of Landsat in the hands of the responsible operator. NASA will continue to conduct research and development, particularly in long-term high risk areas.

A parallel may be seen in NASA's aeronautics program. NASA aeronautics research and technology programs support a government's role in aeronautics, i.e., defense. NASA also has a long history of working with the aeronautics industry--especially engine and airframe manufacturers. As the technology becomes "operational," aircraft are then marketed by the manufacturers to the airlines which serve the public. This is parallel to NASA working with NOAA or a private firm which has operational responsibilities.

QUESTION E-7:

What specific formal arrangements are now in place, and working, in NASA and between NASA and NOAA, to see that our non-Federal public and private sectors are being brought into the delineation of the overall Federal remote sensing research, development and demonstration Applications program? Specifically, how much of this appropriation that NASA is requesting in the Space Applications area would be spent, and how would it be spent, to ensure that our non-Federal public sector and our private sector will be brought in (in Mr. Begg's words) "Clearly enough"...to ensure that the remaining Space Applications funds are being spent "in an effective way"?

ANSWER E-7:

The structure of the budget does not specifically define a level of funds directed to non-Federal public sector or private sector

applications. However, since the issuance of Presidential Directive 54, NASA has focused its own efforts on research and development of remote sensing technology and has reduced its participation in the demonstration and technology transfer activities assumed by NOAA. Non-Federal participation in the delineation of NASA's R&D programs is maintained through participation on advisory committees, and through cooperation on NASA research, development and testing activities.

QUESTION E-8:

There is much discussion of the possible commercialization of our land remote sensing system. Yet everyone seems to agree that this time, there is not enough of a market to support commercial operation of Landsat.

a. Do you agree? Doesn't the COMSAT proposal validate this analysis of the market--they say that they won't take Landsat alone, they want weather satellites and a guaranteed purchase as well?

b. It seems that there is a tremendous amount of information in the landsat images. one picture could have information useful to: farmers, agricultural planners and crop forecasters, lumbermen, hydrologists, petroleum geologists, mineral geologists, transportation planners, recreation planners, land developers, map-makers, etc. With all this potential, why is there no market? One suspects it is because the potential users don't know how to turn this Landsat data into useful information. Do you agree? What programs does NASA have underway or in the 1984 budget to develop the techniques that these geologists and hydrologists etc., can use? What is the funding level, now that AgRISTARS will be cut out?

c. Do you have programs underway to develop new sensors? New sensing techniques? What is the funding in all these projects? Does this include all the Spacelab funding for things like the Shuttle Imaging Radar? What about the programs in Space Research and Technology, the budget book says you have programs there? Please supply an accurate total, together with breakdowns. What is the approximate total?

d. How do the numbers compare--funds for hardware development versus funds to make the hardware useful (i.e. the answer to question (c) above ? Is this a good balance when we don't have a market that will even support Landsat? Do we need more hardware and technology when we haven't even begun to use the technology we have?

e. What are NASA's plans for an ocean remote sensing satellite? Are there potential users? Commercial users?

f. If remote sensing is commercialized and only one company runs the system, will NASA continue to do research? How will you justify this? If you end your research, what will happen to the staff, projects, expertise, etc.?

b. How can it reconcile such a position in the areas of, say, remote sensing, navigation and position-fixing, and materials processing, with the position in space telecommunications where NASA is trying to convince us that a large government-financed program is necessary to maintain our international competitiveness? After all, communications is one of our most sophisticated and successful private-sector space applications areas.

In testimony [before the Subcommittee on Space Science and Applications, 97th Congress, Second Session, August 4, 1982 -- vide page 46 of the printed testimony] less than a year ago, NASA's Administrator, Mr. James M. Beggs, stated that:

"The issue of how we keep this country ahead in those areas where we have, over the last 25 years, had a lead on the rest of the world, is a very, very serious issue ...one that we are very much concerned about in NASA. ...[How do you make sure that...industry has access to our space research and technology development programs] at a very early point so that they can move out and make it commercial. One of the problems that I think we have had is that we have not brought the commercial sector in early enough so that they can make use of these programs in an effective way."

ANSWER E-5:

a. It is NASA's view that sound, effective applications must have a solid research base. We feel that there is a cycle of research and applications in which, as certain research matures, it leads to an array of applications. Meanwhile, more advanced, research areas are undertaken which, in turn, leads to future applications.

In contrast, the process of developing new markets for a specific capability, as opposed to the creation of new applications capabilities, is properly a function of an operating organization. Since NASA is the operating agency for the Space Shuttle, it is proper that NASA devote some of its resources to improving the efficiency of the Space Shuttle in order to make the Space Shuttle function in an economically competitive manner rather than simply performing a government function paid out of the tax base. Therefore, the "marketing activity" as well as improving operational efficiency, are integral parts of NASA's effort to reduce operating costs by expanding the base of Shuttle economic activity.

b. The Advanced Communications Technology Satellite (ACTS), to be developed cooperatively by NASA and U.S. industry, will incorporate new technologies well beyond the state-of-the-art in U.S. satellite communication; new capabilities will be developed. The U.S. industry has conducted R&D to extend proven capabilities but has not undertaken the high risk, long term research and development necessary to maintain its competitive position relative to industries of other nations (e.g., Japan and Germany) which receive government support. The ACTS program will involve cost sharing, and will involve industry early in the process to facilitate the transfer of the new technologies to an existing industrial base. Industry will then implement and market the new technologies.

ANSWER E-8:

a. We have been cooperating with NOAA in a study of the commercial potential of the land remote sensing system. As an operational, rather than a research-oriented agency, NOAA has had far more experience in this area than NASA. At the request of Congress, NOAA is preparing a report on the commercial potential of the land satellite system which is due to be completed this Spring. COMSAT has conducted its own analysis, and their proposal presumably reflects their assessment of the risks involved. While it is generally believed that there is a large potential market for a land remote sensing system, we are not in a position to say whether there is a viable market at this time. This will undoubtedly be addressed in the NOAA report.

b. There is a potential market for Landsat data. The resource information needs are understood, a variety of reasonably priced digital image processing systems are available to show a user how to employ Landsat data in the context of a geographic information system. However, the uncertainty associated with data continuity is believed to have been a principal impediment to the further development of this market. It is believed that the private sector is in a better position to provide the data continuity and further develop this market. As a result, NOAA plans to transfer the Landsat system to the private sector.

The emphasis in our FY 1984 Land Remote Sensing Research Program, which is funded at approximately $12 million, is to conduct basic research aimed at improving our understanding of the remote sensing process; to examine field, aircraft and shuttle/satellite data sources for their potential in addressing a variety of resource information and earth science problems in vegetation science, hydrology, soil science, geology and geography; to develop Thematic Mapper information extraction techniques and to document the improvements and new capability over the multispectral scanner.

c. NASA intends to maintain a vigorous R&D program in advanced remote sensing technology including both new sensors and new sensing techniques. The approximate funding levels proposed in the FY 1984 budget for this program are summarized in this table.

OFFICE OF SPACE SCIENCE AND APPLICATIONS
SPACE APPLICATIONS PROGRAMS
INSTRUMENT DEVELOPMENT FUNDING ($K)

	FY 1984
Land Remote Sensing (e.g., MLA, SIR-B, Imaging Spectrometer)	9300
Upper Atmosphere Research and Analysis	3870
Atmospheric Dynamics and Radiation Research And Analysis	5392
Ocean Processes Research and Analysis	12750

Space Physics/ATD Research and Analysis ?	2600
Shuttle/Spacelab Payload Development	7600
Operational Satellite Improvement Program	600
Earth Radiation Budget Experiment Program	1900
Extended Mission Operations	--
Upper Atmosphere Research Satellite Experiments/ Mission Definition	20000
TOTALS	64012

d. In all NASA Space Science and Applications programs there is a balance between capability development and exploitation which varies from program to program and changes with the passage of time. Currently the program elements which focus on the atmosphere and ocean have an approximately equal split between development and exploitation. Now that the major development costs for Landsat are behind us, the balance in the land area will be shifting toward capability exploitation.

New scientific and applied uses are always being discovered for existing earth remote sensing capabilities.

e. The goal of NASA's Oceanic Processes program is focused on evaluating the utility of spaceborne techniques for observing the oceans and applying these techniques in advancing our understanding of the fundamental behavior of the oceans. In order to minimize total program cost, we are concentrating on those satellite ocean sensors with the greatest near-term potential for contributing to our understanding of the fundamental behavior of the oceans. Thus, we are studying an Ocean Topography Experiment (TOPEX) which is envisioned as a dedicated spacecraft to carry a radar altimeter for the determination of the general circulation or current structure of the global oceans.

We are also studying the deployment of a scatterometer on the Navy's Remote Ocean Sensing System (NROSS) and a color scanner aboard the NOAA series of operational meteorological spacecraft. The scatterometer, which maps the surface wind field, would contribute to the TOPEX objective while at the same time satisfying Navy operational requirements. The color scanner, which maps chlorophyll concentration associated with phytoplankton, can contribute to our understanding of primary productivity in the oceans while at the same time satisfying NOAA operational requirements.

NASA has demonstrated both the feasibility and utility of ocean remote sensing with the success of the Seasat and Nimbus-7 programs in 1978. These satellites provided ocean scientists and operational agencies with views of the oceans that had not been seen previously. Analysis of these data sets continues in anticipation of future

dedicated ocean satellites. The scientific research community, both federal and academic, continue to develop and improve the techniques for interpretation and eventual operational use of the future satellite data. The NASA initiatives of the past decade and the plans for the next decade will result in fundamental advances in our understanding of the oceans.

In the short term, the commercial applications will improve short-range marine forecasts, ship operations and routing in polar regions, commercial fishing operations, and will act as a catalyst for developing new strategies for various marine industries. The impact on many non-ocean operations is more difficult to anticipate, but since the ocean, atmosphere and land are mutually dependent systems, the commercial uses from an operational oceanographic satellite system will continue to develop.

f. The commercialization concept under present consideration applies to the operational meteorological satellite (TIROS and GOES), Landsat, and future operational oceanographic satellites. NASA's research programs in the earth related sciences are more extensive than these systems and involve development of new instrument techniques for specific scientific studies such as the Upper Atmosphere Research Satellite (UARS) and the complementary research needed to understand the basic physical and chemical nature of the Earth. Commercialization will not affect NASA's basic research role and responsibility. It will, therefore, have only minimal impact on the skilled staff NASA employs in these areas.

NASA experience with the commercialization of communication satellites has taught us that terminating and later restarting a research and development activity is costly in both resources and skilled manpower. We will, therefore, attempt to maintain a reasonable level of activity in these areas.

QUESTION E-9:

What is the status of Advanced Communications Technology Satellite ATS-1, ATS-3 and ATS-5? What are they doing?

ANSWER E-9:

The ATS-1 and -3 satellites have been operating for 15 years and are still providing VHF voice communications for a vast array of applications experiments to five continents and the Pacific island region. ATS-1 is used in the Pacific for distance teaching, cultural exchanges, administration, medical and health exchanges, and emergency coordination. Oceanographic and polar studies, linking both polar regions to U.S. research institutions, use both ATS-1 and ATS-3 for data exchange and coordination. ATS-3 serves as a vital link for the nation's emergency communications network, and has been used for primary health care delivery experiments through direct links with local ambulance services and off-shore oil facilities in the southern United States Agencies and organizations involved with ATS-1 and -3 user experiments include National Science Foundation, General Services Administration, Drug Enforcement Agency, Department of Interior, Agency for International Development, States of Alaska and Hawaii, Stanford, American Lutheran Church, Southern Regional Medical Consortium, General Electric, Air Force, and Navy.

International participation is extensive (primarily through ATS-1) and includes the University of Southern Pacific (Fiji), Peacesat (Cook Islands), Latrobe University (Australia), University of Sidney (Australia), and Tohoku University (Japan). Over forty terminals in nineteen Pacific region nations are linked through ATS-1, and they are vividly demonstrating daily the potential of satellite communication for reaching remote and widely scattered populations.

QUESTION E-10:

Concerning the Advanced Technology Satellite (ACTS), a 1984 new start, Mr. Beggs on February 3 mentioned "risk sharing" with industry.

a. What risks do you expect industry to share?

b. Is it true that after a period of time when NASA's experiments were done you would expect industry to take over the ACTS satellite? What would be the benefits to industry, with no ground system developed?

ANSWER E-10:

a. On March 3, we released a Request for Proposal (RFP) to industry for development and operation of an experimental ACTS payload for two years in geostationary orbit. The contractor will also be required to develop and operate a minimum set of ground terminal equipment required to command, track, and manage the experiments. We expect industry to share risks in this program in two ways.

First, we have structured the RFP to allow the contractor to use a spacecraft bus of his choice, and we believe he will provide the bus at some cost savings to the government. We will allow the contractor to add other payloads, either experimental or commercial, to the bus. We have also offered an option for the contractor to take over the assets of the program at the end of the two year period to earn revenue or continue experimenting. By procuring with this flexibility, we have allowed for cost sharing by the manufacturing industry.

Second, we have allowed for cost sharing by the rest of the segments of the communication industry by offering an opportunity to experiment with this advanced technology system if this industry pays for their own ground terminals and data reduction. This approach was used successfully on Communications Technology Satellite.

b. As explained above, we are offering industry the option to take the assets of the program at the end of the two year period to earn revenue or continue to experiment.

The planned technology program will produce the technology that will allow industry to produce ground systems.

QUESTION E-11:

You have often mentioned Materials Processing in Space as an important future activity--as an activity that might be carried out on a space station.

a. How many NASA headquarters people are assigned to run this program?

b. Please comment on the history of its management. Who have been the last few directors of the program, what has been the tenure of each, what have been the gaps between directors, who is director now?

c. Your statement says you will focus on "new types of materials". It would seem that you should give at least equal attention to new types of processes. For example, the Continuous Flow Electrophoresis System (CFES) has been very successful and will be used to separate pharmaceuticals. We are informed that this system can be used to make drugs much purer, and thus better than on earth. So it is the new process that is important, not the material. Do you agree? Are you working on other separation and purification processes? How much NASA money has gone into the CFES?

d. It would seem that pharmaceuticals, with their high value per pound would be naturals for space processing. How much work does NASA have in this area?

e. Is there a strong body of ongoing research in space processing for the separation and purification of organics? Where is it done? Who supports it?

f. How much of your Materials Processing research is conducted at universities, how much in industry?

ANSWER E-11:

a. At the present time, there are three fulltime Headquarters people assigned to the Materials Processing in Space (MPS) program at the professional level. One handles the commercial portion, and two manage the science and hardware development aspects of the program.

b. The present MPS research program was initiated in January 1977, by Dr. John Carruthers when he became Division Director. He remained until July 1981, then was replaced by Dr. Louis Testardi who left NASA in November 1982. Since that time, the Deputy Associate Administrator for Space Science and Applications has been serving as Act?6g Division Director.

c. The ultimate objective of the Materials Processing in Space program is the production of new or improved materials. However, we plan to achieve this objective by studying processing techniques under different conditions including absence of gravity, to better understand the phenomena controlling the processing. This would lead to new processing systems which could produce new and improved materials. Because the intrinsic properties of materials are unique, the detailed operation of a processing system is strongly influenced

by the type of materials to be processed. Materials are therefore chosen, not only because of their capability to be a generic model, but also in many instances, because they are of technological interest, and any improvements resulting from space processing will be of interest to producers.

NASA is studying several types of bioseparating processes including isoelectric focusing and phase partitioning. Under the terms of the Joint Endeavor Agreement, McDonnell Douglas (MDAC) will support the Continuous FLow Electrophoresis System research and build the CFES hardware. However, NASA has the right to separate a predetermined number (8) of samples in the CFES in orbit as part of its bioseparation program. This is done to help characterize separation systems and better define the benefits of space processing. While this activity is part of the continuing research effort, some additional $250K has been budgeted to cover the extra cost associated with space flight experiments.

d. MDAC is evaluating the separation potential of those materials which are of interest to the pharmaceutical industry to determine which could be processed in space by CFES for a profit. The materials are chosen because of their ability to help characterize separation systems; however, in many cases, these materials may have pharmaceutical interest (e.g. growth hormone from pituitary cells).

e. Assuming that organics mean proteins and cells, see d.

f. The MPS program has approximately the following breakdown of research work:

Universities: 55 Principal Investigators
Industries: 10 Principal Investigators

QUESTION E-12:

NASA is phasing out its support of Agristars.

a. What exactly--briefly-is this experiment? Has it been successful?

b. What other agencies will carry it on? At what funding levels? Will any funds come back to NASA to run a reimbursable program?

c. AgRISTARS was a kind of technology transfer program. NASA shut down its formal Technology Transfer program in FY 1983; is cutting Technology Utilization by half in 1984; and is now getting out of AgRISTARS. Yet at the same time the Administration makes the general statement (Science Adviser George Keyworth in testimony on Feb. 2) that we are doing R&D to help the economy recover. How do you explain cutting the very programs that would turn R&D into applied and productive technology?

ANSWER E-12:

a. AgRISTARS is a research and development project which was initiated in FY 1980 to determine the usefulness, cost, and extent to which remote sensing data could be integrated into existing or future USDA information systems. The objective was is to improve the objectivity, reliability, timeliness, and adequacy of these systems to carry out USDA missions. The NASA funded portion of the program concentrated on relatively high risk long-term research and resulted in substantial advances in this technology, e.g., early season separation of key major crops, understanding microwave response to soil moisture, and procedure/technique automation for computer processing. The program was highly successful both in technology development (NASA, USDA) and technology transfer (USDA).

b. The other participating agencies will carry on the program. These agencies include U.S. Department of Agriculture, U.S. Department of Commerce, and U.S. Agency for International Development, NASA will be available to support these agencies on a reimbursable basis. During FY 1984, USDA funding is planned at the $13.2 million level and NOAA funding is planned at the $3.0 million level.

c. The NASA AgRISTARS activity constituted a research and development program to develop new techniques for applying remote sensing data to USDA information needs. The technology transfer function was USDA's and current plans assume the continuation of these activities. The private sector is probably in a better position to turn NASA R&D into applied and productive technology. NASA's R&D will continue to emphasize the long-term, high risk research efforts which are not amenable to private sector support and which serve to maintain NASA's leadership in the development of land remote sensing technology and techniques.

QUESTION E-13:

Your statement discusses the success of Landsat-4. But some systems have failed and TM data transmission is now limited. An identical satellite, called Landsat D prime is in construction and will be completed in 1983. Landsat D prime is a backup for Landsat 4--the idea is that the two satellites will guarantee continuity of remote sensing data until 1988.

a. Is this basically the situation?

b. Due to the partial failure of Landsat 4 do we now face a data gap?

c. The Solar Max mission failed partially a year ago. Wasn't one of the modules that failed a Landsat module? Was similar equipment used on both satellites?

d. Does this indicate that there could be more gaps in data continuity in the future? That is, do we have a possible reliability problem here?

e. Have you made changes in Landsat D prime to prevent similar failures? Are they in the budget? What will they cost?

ANSWER E-13:

a. Yes, Landsat-D prime is in the final stages of testing and should be available for launch - if needed - by early summer. Landsat-D prime will not be launched until Landsat-4 becomes inoperative.

b. The X-band anomaly on Landsat-4 is still under investigation. X-band is the communication link for transmitting the Thematic Mapper data by direct transmission to ground stations prior to the Tracking and Data Relay Satellite System operations. If this communication link should become lost permanently, the Thematic Mapper data can still be transmitted through the Tracking and Data Relay Satellite System when it becomes operational. It should be noted that the Multispectral Scanner operations are unaffected since a different communication link is used for transmitting that data. With the above in mind, no data gap is envisioned.

c. Landsat-4 uses modules nearly identical to those flown on the Solar Max Mission (SMM). However, the SMM failures were corrected on Landsat-4 before it was launched.

d. No, see the response to (c) above.

e. The changes due to SMM experience have been incorporated on Landsat-D prime. Anomalies and failures experienced on Landsat-4 are still under investigation. As soon as a definite cause and effect relationship is established, modifications will be incorporated on Landsat-D prime. Based on our present knowledge, the probable cost of these modifications is not expected to be significant and there appears to be sufficient reserves in the Landsat-D program to cover the cost of these modifications.

QUESTION E-14:

Concerning the success of the Shuttle Imaging Radar (SIR-A), the results are very interesting.

a. Is it true that a great deal of data was taken, and that more could be taken on future flights?

b. Also the Large Format Camera could be flown on the Shuttle and take large amounts of data. And perhaps other remote sensing instruments. Correct?

c. This data will be used in part by the scientists and engineers involved in the R&D projects, correct? But they may not be able to analyse all of it? Usually space experiments return masses of data?

d. Suppose some of this data had commercial value--say to an exploration geologist looking for oil in the Sahara where you got those wonderful images. How would a geologist obtain the data for his own use? Have you thought about trying to sell the data for

commercial use? Perhaps you could sell it to a "wholesaler" who could then package it for individual customers, maybe even giving the U.S. a royalty? Any comments?

ANSWER E-14:

a. The SIR-A experiment was a complete success and a great deal of imagery was acquired. The total surface area covered was about 10 million square kilometers and included all regions of interest. Acquisition of data on the SIR-A mission was basically limited by the eight hour recording capacity of the SIR-A data recorder. There was no provision for separately transmitting the data to a ground station. On future missions, such as the SIR-B which is scheduled for launch in 1984, there will be an onboard digital data handling system that will provide for transmission of data through the Tracking and Data Relay Satellite System. This will greatly increase the amount of data that can be acquired as well as improving the system resolution and bandwidth.

b. This statement is true and is in fact one of the ways we are utilizing the Space Transportation System (STS). The Large Format Camera film capacity enables it to take approximately 2400 large area photographs. NASA is planning to fly the Large Format Camera with other instruments in 1984.

c. NASA develops instruments and conducts space experiments in response to basic and applied research objectives. In order to achieve these research and development objectives it may not be necessary to analyze all the acquired data. These data, however, are also made available to a much larger domestic and international scientific community for both near- and far-term research. It would be difficult to say that a finite portion of data from any given experiment were not analyzed for some research activity over the period of its usefulness.

d. NASA has established the National Space Science Data Center (NSSDC) to further the widest practicable use of data obtained from space science investigations. As one example, all of the Shuttle Imaging Radar (SIR-A) data have been sent to the NSSDC and are available on request for scientists and researchers worldwide. These data are also available to commercial users on a reimbursable basis. The Landsat data are put into the public domain through the Earth Resources Observations System Data Center in Sioux Falls, South Dakota. Through these outlets, data is made available to the public. The idea of selling space science data to a wholesaler who could then package it for individual customers is a complex one involving appropriate institutional mechanisms, etc. At the present time, NASA has no plans for commercializing space science data acquired for research purposes.

QUESTION E-15:

Although funding for data analysis has been increased in NASA's FY 1984 budget, there is no structural reason why such funds may not be subject to continued reduction in the future. A number of university and industry space science teams are in a going-out-of-business mode; some have already been disbanded. One way to protect scientifically

valuable, but unspectacular activities would be to establish separate budgets, one for important continuing activities (including instrument design, data analysis, theory, and perhaps small- to moderate-sized missions), the other for major missions (including hardware, launch, and mission operations). The first of these would be a base budget, which could be maintained even in times of severe funding constraints; the second would be a "budget of opportunity", which would provide for major initiatives as funding allowed. Could you comment on the advantages and disadvantages of such a proposed budget separation?

ANSWER E-15:

Such a separation such as that suggested already exists since there are separate budget lines for research and analysis funding, moderate flight missions such as Explorers, development of major missions, and mission operations. The relative and absolute size of each of these elements is determined annually. They will vary as programs mature, phases shift, new opportunities arise, etc.

QUESTION E-16:

The health of individual space teams throughout the country is not known in any detail. Some evidence suggests, however, that reference only to budget totals does not allow us to determine whether many of these teams can survive. The future needs of space science cannot be foreseen without a detailed analysis of the infrastructure supporting it. Has NASA any plans to provide an analysis of the detailed structure of the U.S. space science establishment, in order to determine whether the national interest in space science is being well served by the general downtrend in overall (constant-dollar) funding for space science since the mid-sixties?

ANSWER E-16:

We agree that there is a need to examine the health of the space science community, particularly the health of university groups, in order to ensure that any capabilities needed for carrying out our future program are retained. Many of the questions you have raised, which are clearly important ones, are now being addressed in detail by a study team which has been put together to examine NASA/university relations in space science. This group is being co-chaired by Drs. Frank McDonald, the NASA Chief Scientist, and Thomas M. Donahue, Chairman of the Space Science Board. An organizational meeting has already been held and we will be pleased to share the results of the study with you when the group is further along in its deliberations.

QUESTION E-17:

The Venus Radar Mapper (VRM) proposed as a new start in the FY 1984 budget, is a scaled-down version of the previously planned Venus Orbiting Imaging Radar (VOIR) mission. In itself, this de-scoping may be a welcome change from previous unwillingness to accomplish, say, 90% of the science at 50% of the cost. However, there is a question of whether a larger structural problem remains unaddressed, namely that larger science projects, like Voyager or Viking, tend to draw funds away from the smaller one.

A significant measure of the past success of NASA's space science program has resulted from a balance of large and small projects undertaken at the same time; a certain concern, therefore, must attend the possibility that, with limited total funding, the few remaining projects may be large, leaving no support for small ones. In this context, the new VRM may represent a redefinition of what major planetary missions of the future may be like. If so, the planetary program may still confront the problem of larger projects preying on smaller ones, but play it out at lower funding levels. In that case, the long-term health of planetary science is hardly assured. Could you comment on these matters?

ANSWER E-17:

With regard to VRM, the cost efficiency of this new mission was not totally derived from descoping. Probably more effective in achieving lower cost is the fact that this mission embodies several of the recommended approaches developed by the Solar System Exploration System. Primary among these are:

o Avoidance of dependence on new technology developments - VRM does not require orbit circularization by aerobraking whereas VOIR did;

o Effective use of current technology - VRM takes maximum advantage of recent developments in Synthetic Aperture Radar data processing which allows operation from an elliptical orbit whereas VOIR required a circular orbit;

o Maximum use of inherited hardware and design - the VRM spacecraft design incorporates existing Voyager and potential spare Galileo hardware or refurbished Galileo engineering models, etc. to a large extent;

o Mission planning with ample margin - the use of the Centaur upper stage affords this mission a great deal of performance margin, so that costly weight savings steps won't have to be taken.

We continue to believe that the proper approach is to have a balanced program recognizing that at any given moment one discipline or the other may be involved in the development of a larger project or set of projects than the other disciplines. At present, the Astrophysics Program is benefitting by the availability of a new capability, that of delivering large observatories to earth orbit. The problem that the planetary program has had to come to grips with is that in recent years, its mission model and planning has included only very large scale projects. Because of this, the Solar System Exploration Committee (SSEC) was formed. The response has been commendable. The "Core Program" defined by the SSEC is expected to become the stable scientific base program that can be afforded for an extended period of time. We expect that there will come a time when augmentations to that c[illegible] program will be appropriate. Assuming that the core progr[illegible] has been firmly established, we would expect such an augme[illegible]tion not to displace the core program but to be added to it. It is [illegible] this approach ultimately, that we hope to assure the long term viability of the planetary program.

QUESTION E-18:

In the 1983 request, NASA cut Planetary Mission Operations (MO) and Research and Analysis (RA) significantly. The Congress added money to mitigate NASA's proposed cuts. This year NASA would cut research $4.8 million while the operations budget would be increased $4.9 million. Thus the sum of MO plus RA is approximately constant. New responsibilities that must be funded from this total ($88.9M) include new developments for the Galileo and ISPM missions and preparations for the Voyager-2 encounter with Uranus. Base money in MO is used to support existing spacecraft such as Pioneers 6 through 11. The result of all this is that there will be significant cuts in certain R&A programs. The following table shows the history over the last few years including effects of inflation.

	1981	1982	1983	1984
Mission Operations (MO)	61.8	42.6	38.5	43.4
Research & Analysis (RA)	50.7	46.7	50.3	45.5
Sum (MO & RA)	112.5	89.3	88.8	88.9
NASA Deflator	1.00	0.91	0.85	0.79
MO &RA, Constant Purchasing Power ($)	112.5	81.2	75.5	70.3

Since 1981 the budget has declined 44% in purchasing power.

a. What has been the impact of this reduction?

b. How can you justify spending hundreds of millions of dollars to build planetary missions and not tens of millions to support the missions?

c. I understand that the Research and Analysis program also is absorbing a $1.4 million effort in Jupiter/Saturn data analysis--doesn't this amount to another cut of $1.4 million making a total cut of $6.4 million on a base of $50.3 million?

d. This is a cut of 12% before effects of inflation, about 19% taking inflation into account. How will this cut be taken? What major facilities will be impacted? Will the Infrared Telescope Facility in Hawaii be closed? If you will not close down large facilities does this mean that the small investigators will bear the brunt of this cut? Will you please give us a breakdown of your RA funding to show how much goes to facilities or institutions such as IRTF, how much goes to more or less independent researchers (e.g. a professor), how much goes to industry, how much to other nonprofit labs, how much to other Federal agencies, etc.?

ANSWER E-18:

a. The Planetary R&A has basically been kept at a constant level. The effect of this has impacted the initiation of new research programs and the expansion of existing research programs. However, we do still have a very viable research base within the Planetary Research and Analysis funding level. The Mission Operations and Data Analysis budget decline is in large part due to

the planned destaffing of the Voyager flight team for the cruise to Uranus of Voyager 2 following its encounter with Saturn.

This level of MO&DA funding will add some element of risk in ongoing mission operations by reducing reserves, thus, reducing flexibility, however, we believe the risk is acceptable.

QUESTION E-19:

The International Solar Polar Mission (ISPM) has been moved from the Physics and Astronomy Program to the Planetary program.

a. Why has ISPM been moved?

b. What impact does this have on the constricted planetary budget from Mission Operations and Research and Analysis?

c. Being partly cancelled in 1982, and shifted from program to program in 1984, ISPM seems to be a stepchild. Does this mean that solar physics, or solar-terrestrial physics has low priority for NASA? Isn't the physics of the sun very important to the earth--to weather, communications, etc?

ANSWER E-19:

a. ISPM was moved to promote management efficiencies associated with the commonalities between Galileo and ISPM. Primary among these are:

- Management Center - JPL manages both projects;
- Launch Vehicle Interface - Both Galileo and ISPM will be launched during the 1986 Jupiter launch opportunity on Centaur;
- Power Sources - Both Galileo and ISPM will utilize identical Radioisotope Thermoelectric Generators (RTGs) developed by the Department of Energy;
- Radiation Hardened Parts - Both projects will utilize parts which have been specially processed and procured under a common agreement;
- Mission Operations - Both projects will be operated from the Jet Propulsion Laboratory.

Given that the Galileo Project has been the primary vehicle for the execution of most of the above, a decision was made to move ISPM into the Planetary Exploration line.

b. There is no impact on either the Planetary Research and Analysis or Mission Operations and Data Analysis as a result of transferring ISPM.

c. NASA is very commited to ISPM as can be seen in answer "a" above. The concellation of the ISPM spacecraft was made in response to the President's Economic Recovery program only.

The physics of the sun still is recognized as a highly important part of NASA's space science program. This is evident based on the commitment of the Agency to the repair of the Solar Maximum Mission, the flight of solar instruments on Spacelab 2, the on-going planning for the Solar Optical Telescope development, etc.

QUESTION E-20:

a. What is NASA doing with respect to the Global Habitability program that the United States proposed at Unispace '82 in Vienna last summer?

b. Please supply a more detailed answer for the record.

ANSWER E-20:

The global habitability concept was initially proposed to delineate current NASA capabilities on the understanding of global processes and to provide a focus for a NASA Earth Sciences program. The concept was based on the growing scientific awareness that significant advances in the Earth Sciences in the next decade would only come about as the result of a multidisciplinary research effort.

The overall concept encompassed a large program, to which NASA would contribute only part, and thus required the participation of other U.S. agencies, other governments, and the scientific community.

Since UNISPACE, NASA has proceeded on three fronts:

(1) A global habitability planning effort has been established. Detailed science plans are being prepared in the areas of global biology, land resources, and atmospheric and ocean processes as related to biogeochemical cycles.

(2) Preliminary discussions on collaboration and coordination of programs have begun with U.S. Department of Agriculture, National Oceanic and Atmospheric Administration, Department of the Interior, and National Science Foundation. NASA has recently initiated discussions with officials within the National Academy of Sciences/National Research Council. We feel that the Academy can play a vital role in further defining the global habitability concept and in providing a vehicle around which to aggregate the U.S. national effort. Furthermore, the Academy is the primary U.S. interface with international scientific organizations.

(3) NASA has also held informal discussions with some interested international organizations (e.g., United Nation Environment Program, Joint Science Committee of the World Meteorological Organization, Food and Agricultural Organization).

The global habitability concept provides a focus for the NASA Earth Sciences Program.

QUESTION E-21:

The Explorer budget has been increased and Mr. Beggs said Feb. 3, that "this program offers important opportunities to address key space science questions in a highly cost effective manner". The budget jumped from $34.3 million to $48.7 million, or 42%.

a. Was this increase recommended by any outside groups? Exactly what are you going to do with the increase?

b. Does this take any pressure off other missions--such as the Advanced X-ray Astronomy Facility?

c. What does this increase imply for future mission operations costs? Will you be able to support these missions? Will you be able to support the researchers?

d. The Planetary community has just done a study (under the Solar System Exploration Committee, chaired by Noel Hinners) that is reported to have come up with good ideas for reducing the cost of planetary missions while keeping a healthy science program. Have you done a similar study for astronomy? Are "Explorers" the answer? Why?

e. Why was the development of the Cosmic Background Explorer (COBE) started "later than planned"? The budget book page RD 3-13 says this late start gave them some budget flexibility. Did the science community change its priorities?

ANSWER E-21:

a. The increase in the Explorer budget was recommended by the Committee on Space Astronomy and Astrophysics (a committee of the Space Science Board of the National Academy of Sciences) and by the Astronomy Survey Committee of the National Academy of Sciences. The increase in the Explorer budget will be used to begin development of the Extreme Ultraviolet Explorer (EUVE) in FY 1984.

b. The Explorer program provides the principal means of conducting astronomical studies and long-term investigations of solar physics and of the near-Earth interplanetary environment having limited, specific objectives and not requiring major observations like the Advanced X-Ray Astrophysics Facility (AXAF). The increase in the Explorer budget will not impact a potential AXAF mission in any way.

c. The mission operations and data analysis funding for EUVE will not be needed until the FY 1987/88 timeframe. This funding request will include researcher suport. We do not anticipate a problem with this approach since by the time EUVE is launched, several of our current satellites will have quit operating and ongoing analysis of existing data will have been completed.

d. Scientific missions under the Explorer Program range in cost from approximately $50-150 million, depending on the specific mission goals of each program. There exists a clear need for missions in this category to complement the major observatory missions, such as Space Telescope. The Explorer queue is filled with high quality science missions, such as the Extreme Ultraviolet Explorer, the X-ray Timing Explorer, the Far Ultraviolet Spectroscopy Explorer, and the Solar Coronal Diagnostics Mission each of which have limited, specific objectives which are a part of the overall strategy as stated by the National Academy of Science Astronomy Survey Committee. NASA is considering both the Hinners report and a report by the Space Science Board's Committee on Solar and Space Physics in its planning of future Explorer missions.

e. Neither NASA nor the science community changed any of the scientific program priorities. NASA followed normal practice within the Explorer program which is to give funding priority to solve technical problems to the satellite program closest to launch, which in this case was the Infrared Astonomical Satellite (IRAS), launched in January 1983.

QUESTION E-22:

The Infrared Astronomy Satellite (IRAS) recently launched, had problems in development. One problem was related to the ability to keep the telescope very cold with liquid helium. The main purpose of IRAS was to do an all-sky survey of infrared sources, and this survey would take some months.

a. Now that IRAS has been up over a month, does it look like you will be able to complete the all-sky survey before the liquid helium runs out? What is the estimated lifetime?

b. When the liquid helium is gone, will the satellite have any value?

c. If the liquid helium is so important, why didn't you design it to be refilled by the shuttle? Why a one-shot gamble that might not have worked?

d. The Infrared Astronomical Satellite (IRAS) appears to be operating quite successfully now, but this program went through a difficult development history that included solving some tough technical problems. Have you gained any valuable experience from IRAS that is relevant to future missions? What are they? Have there been any "revelations" in the IRAS development that may "spinoff" to other non-space areas?

ANSWER E-22:

a. The all-sky survey will be completed in about 200 days of satellite operations. Since the helium flow rate has now stabilized, the lifetime is expected to exceed 300 days.

b. Once the liquid helium is depleted, the internal temperature of the satellite will increase to the point that the infrared detectors will become too noisy to detect infrared sources and will no longer be able to contribute to the mission goals.

c. The addition of the capability to replenish the cryogenic supply on IRAS would have required both a propulsion system on the spacecraft (to bring it down to Shuttle altitude) and a liquid helium transfer system involving the development of a totally new technology. The addition of each of these developments would have made the cost of IRAS development prohibitively high. Perhaps more importantly, the sun synchronous orbit of IRAS would prevent STS servicing until a capability to launch the Shuttle from the western test range is available. This will be long after the expected IRAS lifetime. The design philosophy behind IRAS was to build a spacecraft with sufficient redundancy to obtain a significant body of infrared data with a high probability of success. To date, IRAS has

successfully returned data representing 20 percent of the full sky survey and is on schedule to complete the survey in about six months.

d. The cryogenic technology developed for IRAS will be utilized by the Infrared Telescope to be flown on the Spacelab II mission, by the Cosmic Background Explorer (COBE), and by the Shuttle Infrared Telescope Facility (SIRTF), as well as other future missions. The cryogenic technology used on IRAS may also have application in other space programs such as communications. Considerable data have come from IRAS about the physical properties and operating characteristics of materials at low temperatures which may have application in non-space areas although we cannot name any specific area other than communications.

QUESTION E-23:

Please describe the progress being made in the Space telescope Science Institute.

a. Is satisfactory progress being made in hiring staff? Are you getting good people?

b. Are the European staff arriving?

c. What is the progress on the ground system for operating the Telescope? Will technical problems in the spacecraft cascade down into the ground system?

d. We hear that the staff of the S.T. Science Institute are "working night and day" trying to "catch up". With launch not until 1985, on what are they working so hard? Why are they behind?

ANSWER E-23:

a. Overall, the progress in hiring staff is satisfactory and on plan. The calibre of personnel is very good for all areas, i.e., science, management, business, and other technical disciplines.

b. The European staff are arriving in accordance with the ESA-staffing plan, and the calibre of ESA personnel appears to be very good.

c. The ground system development is progressing well; however, we are currently reviewing this development schedule to make it compatible with the probable launch slip of the Space Telescope.

d. The magnitude of effort required at the start-up phase of the ST Science Institute has been greater than anticipated. Hiring staff, defining management approaches, and establishing a business system have consumed considerable resources time. Due to the dedication of the ST Science Institute staff, they have achieved planned technical accomplishments.

The Institute personnel are tasked to develop some crucial and complex components of the overall ground software system. These components must be designed, developed, coded, tested; and then integrated with the balance of the software and hardware system being

developed by other organizations. The work schedule to accomplish this is tight for a first half 1985 launch of the Space Telescope.

QUESTION E-24:

In the Space Telescope budget you separate "spacecraft" and "experiments", yet your descriptions of the program (e.g. in Mr. Beggs testimony on Feb. 3) usually involve other terms, i.e. "Optical Telescope Assembly" (OTA), "Support Systems Module" (SSM), and "instruments".

a. Could you relate the budget to these other terms?

b. For the record, would you provide this breakout for several years back?

ANSWER E-24:

a. The Space Telescope Development budget is divided between "Spacecraft" and "Instruments." "Spacecraft" consists of the Optical Telescope Assembly (OTA) and the Support Sytems Module (SSM). "Instruments" consist of the four scientific instruments being developed by NASA. These are the Wide Field Planetary Camera, the Faint Object Spectrograph, the High Resolution Spectrograph, and the High Speed Photometer. The fifth Space Telescope Scientific Instrument, the Faint Object Camera, is being developed by the European Space Agency (ESA).

b. The following is a break-out of the above categories for FY 1982 and prior:

SPACE TELESCOPE DEVELOPMENT
(Millions of Real Year Dollars)

	FY 78	FY 79	FY 80	FY 81	FY 82
Support Systems Module	11.2	24.1	35.3	33.0	47.1
Optical Telescope Assembly	14.0	26.1	37.9	47.5	39.2
Science	8.2	23.5	33.4	32.2	29.0
Other	4.3	5.6	5.7	6.5	6.2
TOTAL	37.7	79.3	112.5	119.2	121.5

QUESTION E-25:

Concerning Space Telescope. Mr. Beggs testified earlier that you are experiencing "technical problems" which will lead to a slip in schedule and a launch delay.

a. Do you feel that you have, or will shortly have all the technical problems defined if not solved?

b. Are there any possible advantages or benefits arising from the delay?

c. What FY 1983 and FY 1984 funding adjustments are being made within the Space Telescope budget in order to take care of the problems you are finding?

ANSWER E-25:

a. A review of the Space Telescope development efforts is currently in process with the objective of surfacing all the technical and management problems.

Recognizing that the Space Telescope development effort is a complex research and development undertaking, it is quite possible that we will continue to encounter technical problems from time to time. However, we have not identified any "show stoppers" that will prevent the completion of the Space Telescope in accordance with the original specifications.

b. The major delay is going to take place in the development of the Optical Telescope Assembly. This will cause some slack time in other areas, such as the development of the scientific instruments and the Support Systems Module. We are currently examining the possibility of conducting activities during this slack period to help reduce schedule risk during full up Space Telescope systems testing such as earlier testing of critical interfaces, increased environmental testing of the instruments, etc.

QUESTION E-26:

In Mission Operations you have $13,500,000 for "Space Telescope maintenance and refurbishment" two years before it will fly.

a. Exactly what are you doing?

b. How do you know what spares to buy, etc?

c. Are these costs made part of the development cost, i.e., do they add into the Space Telescope total-cost-to-completion?

ANSWER E-26:

a. The maintenance and refurbishment program is designed to provide a phased capability for performing on-orbit and ground repair and refurbishment of the Space Telescope which requires that a capability be in place, from the very outset, to repair the Space Telescope in case of a failure. This includes a capability to retrieve a potentially failed scientific instrument and/or to replace some of the more critical Orbital Replacement Units. An on-orbit service maintenance capability should be in place within two and one half years after launch including the ability to replace scientific instruments.

b. In developing the Space Telescope spares philosophy extensive analyses were conducted to quantify the reliability of "black boxes" and to assess their projected lifetimes. Those with lifetime assessments of less than 5 years were either supplemented by providing on-board spares on the spacecraft, as in the case of tape recorders and reaction wheels, or by having spares for replacement on-orbit.

c. The Space Telescope maintenance and refurbishment costs are not part of the Space Telescope development cost and are not included in the Space Telescope total-cost-to completion.

QUESTION E-27:

How much of the Mission Operations/Space Telescope Operations request for $38 million goes to the Space Telescope Science Institute? If not all, where does the balance go?

ANSWER E-27:

$10.9 million of the FY 1984 Space Telescope Operations request of $38.0 million is allocated to the Space Telescope Science Institute. Of the remaining $27.1 million, $12.1 million is allocated to the development of the Science Operations Ground System, and the remainder is required for mission operations capability such as the development of porcedures, their documentation, etc., plus reserves.

QUESTION E-28:

You have several kinds of "Spacelab" missions carried on shuttle, and these are somewhat confusing. You have "Spacelab 1, 2, 3..." and you have the "Spacelab payload missions" such as OSTA-1, OSS-1,....etc.

a. Please describe these two kinds of Shuttle payloads so as to differentiate them.

b. Why are they both called "Spacelab"?

c. In NASA what is the relationship between the Spacelab program under the Space Trnasportation System program and Spacelab under Physics and Astronomy, and Applications? For the record could you supply a total Spacelab budget, i.e. pulling all the Spacelab budget items together on one page.

d. For the record please give us a list of the defined Spacelab payloads (including ones already flown). The list should include launch data and a brief description of each.

e. Is the "Tethered Satellite" a Spacelab project? Why?

f. What are the dollar contributions of ESA and NASA to Spacelab 1?

g. How much space station funding is in your 1984 Spacelab request (page RD 3-10)?

ANSWER E-28:

a. The "Spacelab 1, 2, 3..." missions generally take up an entire cargo bay and are, therefore, called "dedicated missions". The Spacelab payload missions, e.g., OSTA-1, OSS-1, OSTA-3, etc. usually consist of one or two pallets and/or a unique equipment support structure; it will usually share the cargo bay with other payloads such as a commercial or NASA satellite.

b. Both types of missions are referred to as "Spacelab" payloads because they utilize the Spacelab equipment provided by ESA.

c. The Spacelab Payload Development and Mission Management activity within Physics and Astronomy provides for mission management and integration activities for all NASA Spacelab payloads as well as development of instruments consistent with the Physics and Astonomy objectives. The Spacelab program within Space Transportation Systems provides for the procurement of the second Spacelab from the European Space Agency, for spares to support the two Spacelab systems, for NASA provided hardware, and for integration and testing activities for the first two Spacelab missions as these missions are designed to test the various Spacelab systems. On the other hand, the Spacelab Operations funding within Space Transportation Systems provides for the integration of the various pieces of Spacelab hardware and instrumentation with the Spacelab module and the Shuttle system.

The Agency budget estimates for FY 1984 are shown on Attachment 1.

Breakdown of Spacelab - Related FY 84 Budget

	FY 84
Physics and Astronomy	92.9
Life Sciences	23.0
Applications	22.6
Total Space Science and Applications	138.5
Spacelab Development	100.2
Spacelab Operations	19.2
Total Space Transportation Systems	119.6
Space Research & Technology	5.5
Total Aeronautical and Space Technology	5.5
TOTAL NASA SPACELAB FUNDING	$236.6M

DEFINED SPACE?AB MISSIONS

d.

Mission	Launch	Mission Science
Spacelab 1	1983	Materials Processing; Astronomy, Plasma Physics, Life Sciences, Earth Observations, Solar Physics, Atmospheric Physics
Spacelab 2	1985	Astronomy, Solar Physics, Plasma Physics

Spacelab 3	1984	Materials Processing, Life Sciences
Spacelab 4	1985	Life Sciences
OSTA-2	1983	
MEA-1	1984	Materials Processing
OSTA-4	1984	
ASTRO	1986	Astronomy, Halley's Comet Observations
OAST-1	1984	Solar Array Technology
OSTA-3	1984	Earth & Environmental Observations
Large Format Camera	1984	Earth Observations
OSS-1	1982	Astronomy, Plasma Physics
OSTA-1	1981	Earth and Environmental Observations

e. No, it is not. This program is a joint U.S. - Italian cooperative project; however, there is no Spacelab equipment involved.

f. The NASA contribution to Spacelab 1 includes the cost of U.S. instruments, mission peculiar equipment, mission management and physical integration of the entire payload complement as well as launch of the mission. ESA's expenditures on instruments are estimated at $75-100 million and the NASA equivalent expenditure is approximately $42 million.

g. $2.0 million of the Spacelab Payload Development and Mission Management funding request is for definition of potential Space Station payloads and their requirements.

QUESTION E-29:

You discovered a "gamma ray burst" recently. You state that "the behavior of this object over the last 50 years challenges our current theories..." This seems to be very important. By going outside the Earth (looking outside) we can see phenomena that our present physics, etc., just can't explain. By explaining these extraterrestrial phenomena, which takes hard work and lots of brains and equipment, we enlarge our knowledge of physics for use here on earth.

a. Wasn't nuclear fusion discovered this way? How?

b. What might the gamma ray bursters tell us?

ANSWER E-29:

a. The initial ideas of nuclear fusion originated in astronomy. Various attempts were made to explain energy production in the Sun and stars by gravitational and chemical means. As scientific understanding improved, it became obvious that gravitational effects were inadequate to sustain the Sun and that the energy released in chemical reactions was inadequate to supply the energy to the Sun for more than a few thousand years. It was not until 1938 that Bethe and Critchfield in the United States and von Weizsaecher in Germany proposed that nuclear reactions would release enough energy to maintain the present rate of energy loss for 100 billion years or more. Briefly, the theory proposed that the net result of a series of nuclear reactions would be the fusion of four hydrogen nuclei into a single helium nucleus, with an accompanying release of energy. The energy released by fusing one gram of hydrogen into helium is approximately equivalent to the energy released by the combustion of 27 tons of coal. The experimental verification of the basic theory of fusion was with the detonation of the first hydrogen bomb.

b. Several theories have been proposed to explain gamma ray bursts. These theories propose models such as surface effects on neutron stars, helium burning, and phenomena resembling a laser; but at much higher energies. If an acceptable theory can be developed, it will tell us about the astronomical environment at the source of the gamma ray burst, as well as possibly aiding in the discovery of new physical processes, which have not yet been discovered on earth but which might find some unexpected application.

QUESTION E-30:

Who is building the Gamma Ray Observatory Spacecraft? The instruments?

ANSWER E-30:

The Gamma Ray Observatory project is being managed by the Goddard Space Flight Center with the spacecraft being built by TRW Incorporated. Major subsystems are being provided by McDonnell Douglas Corporation (power subsystem) and Fairchild Space and Electronic Company (command and data handling subsystem).

There are four scientific instruments being developed:

Oriented Scintillation Spectrometer Experiment (OSSE): Naval Research Laboratory supported by Ball Aerospace Systems Division

Burst and Transient Source Experiment (BATSE): Marshall Space Flight Center

High Energy Gamma Ray Telescope: Goddard Space Flight Center supported by Stanford University

Imaging Compton Telescope (COMPTEL): Max-Planck Institute supported by University of New Hampshire, the Netherlands and Great Britain.

QUESTION E-31:

Unlike other discipline areas covered under the general heading of space sciences (e.g. planetary, astronomy, astrophysics), the scientific community involved in the study of the sun, its extended atmosphere (including the solar wind), the earth's magnetosphere, ionosphere, and atmosphere, and the solid and liquid earth (all of which are more or less related) are not perceived as a coherent entity with clearly defined goals and priorities. In order for us to properly and completely evaluate submissions in these areas we need to have at our access, a concise document that outlines a long range plan that brings an order to this important scientific discipline area.

a. Should perhaps a committee similar to the Field Committee be convened to prepare such a report?

b. If you think such a report already exists, what is it? Are you sure it encompases all the scientific disciplines and physical phenomena that are relevant?

ANSWER E-31:

a. NASA is supportive of plans for such a committee undertaking at the National Academy, and these plans are currently under discussion within the Academy. However, to the best of our knowledge, this committee will be confined to the earth sciences and the radiative output of the Sun and will not include questions of the solar atmosphere, the Sun as a star, the solar wind, nor the plasma environment of the earth.

b. There is no integrated, ordered agenda for the Solar and Earth Sciences such as has been articulated by the Field Report or the Solar System Exploration Committee. Reports for many different parts of this aggregate subject matter are numerous. For the Solar Terrestrial area; ranging from the Sun to the upper atmosphere of the Earth, the Colgate Report (1979) and the Kennel Report (1980) laid out a clear statement of needs. Some of these needs are being addressed by the current NASA program. The Committee on Earth Sciences has recently issued a report on the need for a study of the solid and liquid earth and is preparing a report on a study of the atmosphere. The Field Report included the study of the Sun as a star in its recommendations for astronomy and astrophysics.

The study of the Sun is not the sole province of any single segment of the current NASA program because it is important to all areas of Space Science. In the Sun-Earth relations context there are questions dealing with the particles and fields and radiative outputs of the Sun. In astronomy and astrophysics, there are questions about the fundamental structure of stars and their life cycles where the Sun offers a unique observational opportunity. In Planetary research, the total structure of the heliosphere is the question, with the Sun serving as the source of many of the factors shaping the planets and their environments.

QUESTION E-32:

a. What specific benefits will a Space Station provide for the science and applications program that Shuttle can't provide?

b. What would be the relative benefits if Shuttle's in-orbit-time could be extended? What about Space Station versus Shuttle combined with an unmanned platform that could be serviced by Shuttle?

c. Might it not be cheaper overall to buy a fifth orbiter and develop the small amount of technology needed to extend the on-orbit-time as compared to building a space station from scratch? (Keeping orbiters in space longer might stress the schedule for launches. Having a fifth orbiter would give resilience to the system.)

d. Have we really even begun to explore what the Shuttle plus associated support equipment, such as SPARTAN, etc., can do for science and applications?

ANSWER E-32:

a. The space station would provide a permanent presence in space with the potential for continual manned interaction. Some of the science and applications benefits which would be provided by this capability are: the enabling of assembling and constructing large apertures and reflectors in space for the benefit of astronomy and communications; the ability to service and support complex observatories in low-Earth orbit such as the Space Telescope, The Advanced X-Ray Astrophysics Facility, the Shuttle Infrared Telescope Facility and the Solar Optical Telescope; the provision of a transportation node in low Earth orbit, thus providing the capability to deliver large masses at large hyperbolic excess velocities for the benefit of planetary exploration and future communications platforms that will be placed at geosynchronous altitude; and the provision for developing new pharmaceuticals by providing the capability for manned interaction in the development of new materials processes.

b. The Shuttle stay time cannot reasonably be extended beyond approximately 20 days. There are many functions in all areas of science and applications that could benefit from stay times considerably longer than 20 days. One example is the refueling, testing, payload integration and deployment of a space based orbiter transfer vehicle using the Space Station as a transportation node.

The space station concept currently under study is a distributed architecture concept including a manned base and unmanned platforms. While the unmanned platforms could be serviced by the Shuttle, the permanent presence aspect of a space station appears to have the potential to provide a much more efficient and cost effective servicing function for astronomical, Earth observations and materials processing platforms.

c. Achievement of a true on-orbit research and development capability and cost effective space operations requires a space station. In addition, facilities and accommodations for longer

duration stay time are limited on the Shuttle. Its design and primary use as a transportation system inherently means that the Space Shuttle is not a long-term orbital laboratory. It is not believed that a "small amount of technology" would significnatly increase the Shuttle stay-time on-orbit as compared to a space station.

d. The Shuttle, plus associated equipment such as SPARTAN, provides an excellent capability for conducting missions that have in the past been conducted by sounding rockets. As a matter of fact, these missions will lead toward the development of new instruments that might be placed in future large observatories. Therefore, the SPARTAN concept is an excellent concept for implementing current requirements will ultimately require complex observatories.

QUESTION E-33:

As near as we can tell, the management responsibility for Space Telescope development is diffuse if not confusing, in that the contractor responsible for overall integration has no authority over other contractors. Has this had any impact on the problems now looming over us?

ANSWER E-33:

Management responsibilities in the Space Telescope program are allocated as follows: Marshall Space Flight Center (MSFC) has over-all directional authority over the associate contractors, Lockheed Missile and Space Company (LMSC), and Perkin Elmer (PE). LMSC has responsibility for systems level engineering of the ST which includes ST systems level analyses; establishment of ST acceptance and verification requirements as well as orbital verification requirements; systems level audits of weight and power; development of interface control documents; and coordination and advice to MSFC on all aspects of ST systems level management. This responsibility does not include direction to the other associate contractors, which This arrangement differs from the "prime contractor" approach, under which the responsibilities for direction, integration, coordination and development of requirements all reside in one company. One pit-fall of this approach which has been encountered in varying degrees in the ST program, is a reluctance to aggressively interact across contractual interfaces to assure visibility into all aspects of the program. Indeed, these interfaces have sometimes proven to be barriers to effective communication. Another disadvantage is that systems analyses, audits, and test plans suffer from incomplete data sets which must be supplied by associate contractors. These difficulties are being overcome by more emphasis on establishing sizeable liaison groups between contractors, and on an intensified effort at MSFC to follow-up on and validate systems engineering activities.

QUESTION E-34:

On page 14 of your statement you list AXAF as the "top priority major new program recommended" by the Field Committee. True. But the Field Committee also mentioned several "prerequisites" for new programs.

a. What are these prerequisites?

b. What are you doing about these?

ANSWER E-34:

a. The prerequisites mentioned by the Field Committee are 1) to develop instruments and detectors, 2) to support theory and data analysis, 3) to support new computational facilities, 4) to support laboratory astrophysics, and 5) to provide technical support at ground-based observatories. Development of instruments and detectors in Item 1 receives a great deal of support, not only from the Office of Space Science and Applications but also from the Office of Aeronautics and Space Technology. We are developing instruments in every class highlighted by the Field Committee report. For Item 2, we believe that our proposed budget has the proper level of funding for analysis of our missions. We are investigating how to implement an enhanced program of astrophysical theory along the lines recommended by the Field Committee beyond the support we now give through our Supporting Research and Technology program. In reference to Item 3, we support computational facilities that are needed for our astrophysical investigations, such as the advanced facility for the Space Telescope Institute. Laboratory astrophysics (Item 4) is an area we fund in our Supporting Research and Technology program. We do have a need for atomic and molecular spectroscopic information to interpret our data, and we are investigating an enhanced program along the lines recommended by the Field Committee. Item 5 is directed specifically at the National Science Foundation, but NASA is providing technical support at its ground-based observatories, including the Infrared Telescope Facility.

Mr. VOLKMER. Thank you very much, Dr. Edelson. We will start questioning under the 5-minute rule.

Mr. Bateman, do you have any questions?

Mr. BATEMAN. Mr. Chairman, I would yield to Mr. Winn at this point.

Mr. VOLKMER. Do you have any questions, Mr. Winn?

Mr. WINN. No, Mr. Chairman.

Mr. VOLKMER. The gentleman from California, Mr. Mineta, please.

Mr. MINETA. Mr. Chairman, I apologize for being here a little late.

Dr. Edelson, let me just ask about the space telescope and the cost overruns there.

Apparently we have I guess some technical problems. You may have covered them in the testimony and I apologize for not having been here earlier—but have those technical areas, whatever those problems are, have they been addressed and corrected or are we still going to be seeing some more serious, continued serious overruns in the space telescope program?

Dr. EDELSON. We are in the middle of a review of the space telescope project now, Mr. Mineta, and we are very much concerned about the problems that we are currently having. As Mr. Beggs mentioned in his testimony before the full committee earlier and as I mentioned in my prepared testimony, we have that project under intensive review now. Our concern stems from the fact that

the testing, integration, and assembly of the optical telescope assembly OTA is more difficult and time consuming than we had anticipated. At the present time it appears that delivery of the telescope from the developer, the Perkin-Elmer Co., to the Lockheed plant in California where it will be assembled and integrated with the five instruments, and then realigned and tested, will be much later than planned.

Our concern now is to get all the facts out on the table so we can understand just what the problems are at Perkin-Elmer. The problems appear to be largely in alinement, testing, and production problems in the fine guidance sensor electronics being manufactured by the Harrison Corp., a subcontractor. We are making an assessment of what the difficulties are to determine a realistic schedule. We had planned to have a complete OTA shipped from Danbury, Conn., to Sunnyvale, Calif., but it is now quite possible that we will not integrate two of the fine guidance sensors but will do so on the West Coast. Therefore, we can ameliorate some of the schedule problems.

Mr. MINETA. Do you have a schedule, revised schedule as to when all that will be done? I take it you have an idea of what the magnitude of the problem is?

Dr. EDELSON. We are just beginning to understand the magnitude of the problem. In fact tomorrow Mr. Beggs, myself, and a number of other individuals who are involved in the program management at headquarters and the Marshall Space Flight Center are meeting at the Perkin-Elmer plant in Danbury to review the situation to try to understand the impact on the schedule.

The dates that we have been working toward, Mr. Mineta, are delivery of the space telescope in December of this year which would have allowed a launch in the first half of 1985. It appears certain now that the completion of the work at Perkin-Elmer will take longer than anticipated. Whether it will be a month or two late, or 5 or 6, is simply not known at this time; nor do we know how the magnitude of that slippage will affect either the ability of Lockheed to put the telescope together or the eventual launch date. However, we will slip the launch date some.

As far as cost is concerned, that will depend, to a very large extent on schedule, because time is money in a large fabrication-development-assembly-integration effort such as this. The cost per month in slippage is considerable and will be a significant part of any extra costs we encounter.

Mr. MINETA. Are you satisfied that you have addressed the technical areas? As I understand it, there were serious technical problems. I guess I am asking, have we addressed those serious technical problems and are you satisfied—as far as what you have done or what you know of the analysis of what is happening right now?

Dr. EDELSON. Yes we are addressing the technical problems.

Mr. MINETA. Is it the payload or the vehicle? Have we isolated it? It is really more payload, is it not?

Dr. EDELSON. Yes, the major technical problem we have now is completing the three fine guidance sensors which are integrated with the telescope. Other than that, it is largely a question of instrumentation to calibrate and aline the telescope rather than obstacles to overcome in the telescope development itself.

Although we have the problem I described, I think, it is worthwhile to point out that we have made very significant strides. The mirror is in excellent shape having been finished accurate to a very small fraction of a wavelength and better than we expected.

There are no technical problems in materials or devices, other than the latch problem, which we are working, that represents an obstacle that we would have to overcome, such as developing a new material or a new device or new capability. It is a question of getting it together.

Mr. MINETA. Then the question is when do you think it is all going to come together? When do you think you will have an idea—given all these problems—that you will have than an idea of the magnitude of the problems? How to address them and a schedule for that?

Dr. EDELSON. I think we will have the answer to that question next month. We are putting all the facts together in the next couple of weeks; and, I think, it would be fair to say it will take a week or two to analyze it, reorganize, and determine to a new schedule. We will certainly keep the subcommittee apprised of our progress on this matter. Mr. Beggs promised that we will specifically report the results of our study and the impact on the schedule and the cost.

Mr. MINETA. While we are on the space telescope, let me ask about the Space-Telescope Science Institute. Is satisfactory progress being made in hiring staff for this Space Telescope Science Institute?

Dr. EDELSON. Yes; we are making good progress in hiring the staff. I believe that the total number of staff that they will eventually have is 184. As of the end of December, there were 50 on board and they recently hired quite a number of people. There are probably 60 to 70 on board at the present time.

Mr. MINETA. Good competent people?

Dr. EDELSON. Yes, indeed, very high quality.

Mr. MINETA. What about the European staff that is coming?

Dr. EDELSON. They have had a rather slow start in assigning people but now they have six assigned, and all high quality people. They are very enthusiastic about it.

Mr. MINETA. They are also good people?

Dr. EDELSON. Yes, sir.

Mr. MINETA. What about the progress on the ground systems for operating the telescope? Are the problems you are having in the technical areas of the payload and vehicle side, are they going to have an impact on any problems on the ground side?

Dr. EDELSON. No, Mr. Mineta, in fact quite the opposite. If there is any slip involved, it will just make it easier to get the ground system lined up, tested and working. There are in effect, really two ground systems: The science operations ground system and the mission operations ground system. The science data are delivered through Goddard to the Space Telescope Institute in Baltimore. The mission operations and control data that come from the spacecraft are used to control and operate it and to keep it accurately pointed and operating effectively in orbit. That work is done at Goddard.

It would be impossible really to calibrate the system and to figure out exactly how it will work until we have some experience with TDRS. The first TDRS will be launched on STS–6 and the second on STS–8. We will put two tracking and data relay satellites in orbit. The space telescope is controlled through a link that goes through the tracking and data relay satellites and all the data must be returned through the TDRS. That is a complicated procedure. We have to develop the analysis and processing systems on the ground to be used in flight. That work is going well; but, it is tedious and difficult and requires an extensive integration effort. There are some difficult hardware-software interfaces in those links. But, that work is on schedule and proceeding smoothly.

Mr. MINETA. Thank you very much, Dr. Edelson.

Mr. Chairman, I appreciate your patience in allowing me my full 5 minutes.

I do have more questions that I would like to submit for the record.

Mr. VOLKMER. Submit them in writing and I am sure Dr. Edelson will reply for the record.

At this time we recognize Mr. Brown, the other gentleman from California, for any questions he may have.

Mr. BROWN. Thank you, Mr. Chairman.

Dr. Edelson, just to pick a couple areas I have been interested in.

With regard to the advanced communications technology satellite, can you give us briefly an indication of what the goals are in that operation?

Dr. EDELSON. I think I can, Mr. Brown. The overall goal of the program is to maintain and insofar as we may be lagging, to recover, U.S. leadership in the field of satellite communications.

The United States was the undisputed leader in this technology for many years, all during the 1960's and up to the mid-to-late 1970's. The fact is that other nations, particularly the Europeans and Japanese have made major inroads and have all flown experimental satellites. They have done really quite excellent work in pushing the technology ahead of ours. Thus, we have lost out on some critical areas. In particular, we have lost out in satellite power tubes, traveling wave tubes, onboard solid state devices for FET amplifiers, and other technical items built into satellite communications.

The specific objective of the ACTS program is not to make minor extrapolations of existing technology but to leap to the next generation of technology in the opening up of a new frequency band, the 30/20 gigahertz band with 4,500 megahertz of available band width. We want to develop a new antenna and feed network technology which will allow the accurate pointing of an antenna beam and control of beams in terms of weighting and shaping of the beams, an onboard satellite switch—a time division multiple access switch—which will allow switching between beams on the satellite, and perhaps most significant of all, the onboard signal processing. This will allow a communications satellite to have a digital computer on board which acts as a switchboard. In effect, many of the communications processing functions, for example, switching, signaling, coding, regeneration and so on, would be done on this spacecraft computer much like it is now done at a major communi-

cations station on the ground. We intend to issue an RFP shortly for this payload. It will be NASA's attempt to have some type of cost-sharing arrangement with industry. Specifically, we hope to enter into a contract with the manufacturer to develop and fly the payload. We will only specify the advanced technology payload. We will only specify the advanced technology payload. We will not specify the spacecraft, so that, for example, the manufacturer might use an existing communications satellite bus that will support the NASA payload. We will pay him to develop the payload and fly it for 2 years, during which time it will be tested. After that, the manufacturer may use the spacecraft for commercial purposes himself.

So we expect to get a very good price for this arrangement. There has been very active interest on the part of three or four of the major satellite manufacturers. We hope to get a very cost effective and technically advanced contract out of this.

Mr. BROWN. If this great leap forward succeeds and we are able to deploy a new generation of advanced communications technologies, what does that do for our satellite communications capability in terms of just volume of satellite communication and access to orbital slots?

Dr. EDELSON. As you may know, the geostationary orbit arc is crowded.

Mr. BROWN. Almost saturated.

Dr. EDELSON. In addition to the geosynchronous arc, the 6/4 and 14/12 frequency bands will be saturated. There is an attempt to move the spacecraft closer together by 2° rather than 4° apart, and to try to use more efficient and effective transmission schemes. But, basically the only way that major progress can be made is to open up new bands and develop the on-board processing which will use them more efficiently.

The answer to the question is that we will increase by an order of magnitude the capability of any one position in the geostationary orbit arc to carry communications traffic.

Mr. BROWN. An order of magnitude?

Dr. EDELSON. Yes, sir.

Mr. BROWN. That will last us for 5 or 10 years, then, won't it?

Dr. EDELSON. That is exactly right. In operational use of communications satellites, we have increased capacity by more than an order of magnitude; in other words, more than 10 times in 10 years.

Mr. BROWN. Now, you have been very close to this for quite a few years and you know that the NASA role in advanced satellite communications R&D went up and then it dropped down again. Then we recently resumed expenditures in this area in a substantial way.

Part of the reason for that was that we had an excellent, profitable organization known as COMSAT, with which you are familiar, operating in the field.

The question arises as to how the burden of advanced communication R&D should be shared between the private entity and the Government. Could you speak to that point as to your own views on the matter?

Dr. EDELSON. Mr. Brown, I think that the ACTS program represents our answer to that. NASA was responsible for developing the

technology that made COMSAT and all present communications systems feasible. In early projects like ECHO, Relay, Syncom, and others, we provided the basic technology that made the first communications satellite feasible.

Then, from approximately 1964 to 1973, NASA pursued a program under the title of ATS, applications technology satellites, which developed technology in spacecraft stabilization and high-powered tubes, for example, and many of the other technologies that were used in the program.

In 1973, the administration and NASA decided that the health of the communications satellite industry was fine and that it would not be necessary for the Government to spend taxpayers' money to support what private industry appeared willing to support. From 1973 to the present time, NASA did not spend large amounts of money in communications satellite technology development and did not fly any experimental communications satellites. During that period of time, the Canadians flew the CTS experimental satellite. NASA participated in that program but not as a major partner. Germany and France flew the Symphony satellite. Japan flew several communications satellites and broadcast experimentation satellites. There were a dozen or so experimental satellites flown by other nations, each of which made a step forward.

Then we began to realize that although the communications companies such as COMSAT were willing and able to make minor extrapolations of the technology—they would take a device and improve it; they would take an existing kind of antenna and improve its surface tolerance and develop a new feed network direction system—the companies were unable and certainly unwilling to make a major leap ahead.

COMSAT, for example, spends around $10 million a year of its own stockholders' money on research and development. A single experimental communications satellite will cost several $100 million. So it is impossible for a small company, or even for a large company like RCA or Western Union, or any other companies that are involved in satellite communications, to make a major step forward. Those steps tend to be very risky, very expensive and, even more interesting, tends to benefit the industry in general. Across the board, however, the communications companies are helpful across the board. But they will not pay for the kind of research that will not benefit the competitive position of that particular company relative to other communications companies.

Mr. BROWN. May I, in deference to the time, ask you to suspend that point? Because I want to ask one final question.

I think you have done an excellent job of answering that question, and in fact all of them you have.

Would it be your conclusion that in those circumstances which meet the criteria you have outlined the Government is justified in spending taxpayers' money, in cooperation with industry if necessary, in order to keep this Nation ahead of the rest of the world in terms of future commerical opportunities?

Dr. EDELSON. I would say yes.

The ACTS program is just that. NASA is spending the taxpayers' money to make the major breakthrough to support the high-risk, very advanced technology, but we are requiring cost sharing on the

part of the satellite industry and common carriers to test the satellite.

Mr. BROWN. I would have pursued a similar line of questioning with respect to Landsat and some others if I had had time, but I will not do so at this point.

Mr. VOLKMER. The Chair now recognizes the gentleman from Texas, Mr. Andrews.

Mr. ANDREWS. I don't have any questions. I would yield my time back to Mr. Brown, if he wants to pursue his questions.

Mr. BROWN. Mr. Chairman, I defer to your wisdom as to whether I ought to have any more time.

Mr. VOLKMER. I think we ought to move along. We have another witness after this one.

Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

Just quickly—Mr. Chairman, tell me if the questions I ask have been asked, I don't want to cover topics that were gone over.

Have we discussed the Venus radar mapper?

Mr. VOLKMER. No; he testified on it, but there have been no questions on it.

Mr. WALKER. Let me say that I think that it is a good step forward from the standpoint that I think we will get a lot of science for about half the cost. I think that is the good direction for us to be looking to go.

But I want to ask a question here about your testimony in which you indicated that we are going to be using flight-approved units left over from the Galileo and International Solar-Polar Mission for the Venus radar mapper.

If we have not yet launched Galileo and the International Solar-Polar Mission, how are we going to go about using leftover units? How will we know what is left over? How will we be able to cost that out and come out with a proposal of the kind you mention in your testimony?

Dr. EDELSON. Mr. Walker, in explaining how we are going to lower the cost of the VRM and keep it at a reasonable level, we pointed out that we are going to use maximum inheritance of existing hardware and existing designs.

In some cases—I would be glad to submit the list for the record—we are using extra units, not leftover unit. We didn't order too many by mistake; but, in many cases, you order spares and you have backup units that are being built for certain pieces of hardware. We have those at JPL and some which will actually be used as part of VRM. In other cases, in fact many more cases, we are not using hardware which was previously purchased and is left over, but we are using designs to make it identical.

[The information follows:]

VENUS RADAR MAPPER

SPACECRAFT SYSTEM INHERITED DESIGNS

Design:
Temp Control Louvers, Viking Orbiter and Voyager.
Attitude Ref Unit, Classified Project.
Star Scanner, Inertial Upper Stage.
Sun Sensor, DOD Satellite and Heat Capacity Mapping Mission.

Sun Sensor Electroncis, Heat Capacity Mapping Mission.
Reaction Wheels, NASA Standard.
Prop Tank, Shuttle Auxiliary Power Unit.
Pyro Initiators and Detonators, NASA Standard.
Battery Cells, NASA Standard.
PWR Control Unit and Shunt Reg, DOD Satellite.
Transponder, NASA.
RF Components, Voyager and International Solar Polar Mission.
Tape Recorder, Galileo.

SPACECRAFT INHERITANCE

Potential and Available Hardware Items:
Command and Data System, Galileo (flight spare may be available).
Command and Data System Support Equipment, Galileo (ground test equipment).
Attitude Control Processor, Galileo (flight spare may be available).
Travelling Wave Tube, International Solar Polar Mission (from canceled spacecraft).
Power Subsystem, Galileo (flight spare may be available).
Bus Structure, Voyager (proof test model).
High Gain Antenna, Voyager (flight spare) and Galileo (proof test models).
Propulsion Components, Voyager (flight spare) and Galileo (proof test models).
[NOTE.—Galileo flight spares will be available unless needed for Galileo, in which case a reproduction or modification of that unit would be required; thus, eliminate the requirement to design a new article of hardware.]

Manufacturing the second and third unit is always much cheaper than manufacturing the original unit which has to be developed and tested and so on.

Mr. WALKER. I don't quarrel with that. I guess my question is, how do we know they are spares until the missions are completed that you pull the spare from?

Dr. EDELSON. In the case of Galileo hardware, we have the flight hardware completed, we are building a protoflight model, and the hardware is being integrated and assembled.

So units that we previously purchased for testing or for possible use in case we needed them will be available. If those units are not available, we can order them. But in any case, we will use the same configuration and same design to, thereby, save money.

Mr. WALKER. Let me ask you about the infrared astronomy satellite that you mentioned in your testimony as being a major leap forward, and I think we can all be pleased that that is taking place.

I understand it is cooled with liquid helium, is that right?

Dr. EDELSON. Yes, sir.

Mr. WALKER. Now, are we going to be able to complete the all-sky survey before that liquid helium runs out?

Dr. EDELSON. Yes, we think that we will, Mr. Walker. Experience in orbit, since we launched it last month, has been excellent. It is running colder than we anticipated, and the heat transfer or the raising of temperature is slower than we thought it would be. We were aiming for at least a 200-day orbit. We feel now that we will get something in excess of 300 days of useful service in orbit, which is specifically controlled by the liquid helium and the need to keep down to 2° absolute temperature.

I note that today's front page of the New York Times, a copy of which I have here, covers the exciting and interesting results that we are just beginning to obtain with IRAS now, and Dr. Allen will mention it in his testimony as well.

[The information follows:]

[From the New York Times, Feb. 22, 1983]

Orbiting Telescope Glimpses Birth in Space

(By John Noble Wilford)

In its first days of operation, a new telescope orbiting the earth has returned infrared images showing previously unobserved features of distant galaxies and revealing cosmic "maternity wards" where clouds of interstellar gas and dust appear to be in various stages of giving birth to stars.

In just one minute of observation, moreover, the Infrared Astronomical Satellite, which was launched Jan. 25, collected more information on infrared emissions from the Large Magellanic Cloud, the nearest galaxy to our own Milky Way, than had ever been obtained in the years of looking through instruments on the ground, in balloons or high-altitude aircraft.

Infrared radiations are invisible to the human eye, and such radiations coming from space are virtually undetectable on the earth because they are mostly absorbed in the atmosphere.

The pattern of intense infrared, or heat, emissions from one region of the Large Magellanic Cloud, a nebula of dense dust and gas known as Tarantula, appeared to confirm predictions that it was a region where many new stars were forming, according to astronomers on the project. Further analysis may resolve a scientific debate as to whether the nebula has recently spawned a cluster of massive stars, each 10 to 100 times heavier than the sun, or a single "monster" star thousands of time more massive than the sun.

In the satellite's first 12 hours of operation, its 22-inch telescope also gathered data on at least 20 other gallaxies, some of which are barely visible to optical telescopes.

Astronomers hailed the spacecraft's early performance in interviews last week at the Jet Propulsion Laboratory in Pasadena, Calif., and at a news conference yesterday at Chilton, England, the primary tracking station for the mission.

Dr. Gerry Neugebauer, an astronomer at the California Institute of Technology and one of the chief project scientists, said the spacecraft was "working extremely well," that the telescope's pointing accuracy exceeded expectations and that the vehicle should be able to operate at least 10 months, three months longer than originally expected.

The one-ton spacecraft is circling the earth from pole to pole once every 103 minutes at an altitude of 560 miles. Its goal is to scan 95 percent of the sky and produce the first comprehensive map of perhaps a million objects in the heavens—dust clouds, stars and galaxies—as active infrared emitters that could be signaling clues to the dynamic processes involved in the birth and death of stars.

Looking in areas closer to home, it should also detect the heat "signatures" of thousands of asteroids that have never been seen and search for the long-suspected 10th planet, a body that is assumed by many astronomers to exist beyond the orbits of Neptune and Pluto.

For making its observations, the spacecraft has an array of 62 detectors at the base of the telescope that are capable of sensing infrared radiation in four wavelengths. The detected radiations are converted to electronic data, recorded on board and then transmitted to the ground each time the spacecraft passes within radio range of the Chilton tracking station. On the ground, the digital data are then processed by computers and displayed as graphs showing highs and lows of infrared intensities or as images that are color-coded to characterize different radiation levels.

NEW WINDOW ON UNIVERSE

So far, the telescope had seen "no major discoveries or unexpected things," Dr. Harm Habing, an astronomer at the Huygens Laboratory in Leiden, said at the news conference. But by opening a new window on the universe, observing clearly for the first time in infrared wavelengths of the electromagnetic spectrum, the telescope is expected to find many stars and galaxies that had gone undetected and probe the center of the Milky Way, where vast amounts of dust obscure the countries objects that makes the region a source of so much mysterious energy.

Dr. Neugebauer said trying to do infrared astronomy from ground-based telescopes, as in the past, was like "trying to do optical astronomy during the daytime."

The project is an $80-million multinational endeavor in which the United States built the telescope and is managing operations, the Netherlands built the spacecraft

and three other scientific instruments and Britain is tracking the spacecraft and collecting its radioed data.

One of the first infrared images released yesterday showed features in a bright nebula of the Large Magellanic Cloud that is officially designated 30 Doradus, but that is nicknamed the Tarantula because long, separated filaments of the nebula give it a spiderlike appearance. The nebula is 155,000 light years from the earth, a light year being the distance light, traveling at 186,000 miles a second, covers in a year.

The image was reconstructed at the Jet Propulsion Laboratory from electronic data transmitted by the spacecraft, with different false colors applied to accentuate gradations of infrared intensities. White demotes the brightest infrared sources; blue, the faintest.

Dozens of the infrared objects that appear in the image are from areas where nothing can be seen with optical telescopes. Most of these sources, project astronomers said, are probably newly forming stars still shrouded in the cloud of gas and dust from which they are condensing.

According to Dr. B. Tom Soifer, a senior research associate at the California Institute of Technology, spacecraft sensors set to detect different wavelengths of infrared radiation have most likely observed three different stages of stellar evolution occurring in the Tarantula region. Instruments sensitive to the longest wavelengths, he said, detected what appear to be "molecular clouds just deciding to collapse and form stars." Medium wavelengths revealed the matter coalescing into denser features. Then, in the shortest infrared wavelengths, Dr. Soifer said, the images show stars that have just formed.

Theory holds that gravitational collapse causes the clouds of dust and gas to coalesce and form new stars. Once the new stars are massive enough and hot enough, thermonuclear reactions begin and they glow in the visible portion of the spectrum. In the early stages of their evolution, however, when they are cooler, they radiate mainly in the infrared.

Dr. Soifer said the new images confirmed that the Tarantula was indeed "an active region of star formation." As the survey progresses, the data will be compared with observations of star formations in other regions and other galaxies before astronomers expect to draw any conclusions about the nature of star birth or other celestial phenomena.

Mr. WALKER. Once the helium is gone, will the satellite have any use?

Dr. EDELSON. No.

Mr. WALKER. That being the case, why was there not provision made for replenishing the helium by using the Shuttle?

Dr. EDELSON. That is a really good question. We would like to do that, of course; and, in the future, we may be able to do that. But, the capability of doing that is well beyond our knowledge and experience at this time. It is very intricate and very difficult to handle cryogenics in orbit. IRAS is really an Explorer satellite. We spent about $80 million on its development. The capability to pump helium into it in orbit would cost hundreds of millions of dollars at this time.

Mr. WALKER. So it is a financial and technological problem. In other words we don't have the technology to do it.

Dr. EDELSON. It is 10 years away, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. VOLKMER. Mr. Nelson.

Mr. NELSON. Thank you, Mr. Chairman.

Dr. Edelson, the budget in constant dollars after you factor out inflation for the Planetary Mission operations and research and analysis has gone steadily downward over the last 4 fiscal years. Basically using 1981 as the base point you had $112.5 million; and that has come down in fiscal year 1984 according to your request, to $70.3 million. That is in constant dollars after you factor out inflation.

Your request is $88.9 million.

Dr. EDELSON. Yes.

Mr. NELSON. In purchasing power as compared to 1981 dollars, however, that is now down to $70.3 million.

Dr. EDELSON. Yes, I believe that you are adding the total research and analysis and mission operation and data analysis together.

Mr. NELSON. That is correct.

Dr. EDELSON. And that is $88.9 million today.

Mr. NELSON. And in purchasing power, in order to compare where NASA is going in this particular program, you compare that to 1981 and we have gone steadily downward.

Dr. EDELSON. Yes.

Mr. NELSON. In other words, the $88.9 that you have in the budget would only purchase $70.3 million worth of 1981 dollars. So we have had a decrease of purchasing power in this program considerably over the last 4 years.

Can you tell me why?

Dr. EDELSON. Yes, Mr. Nelson. Let me state at the beginning that we are and have been very concerned about the support for our research base in planetary science. We believe that the 1984 planetary science program is healthy and is on the way back to real recovery. Now having said that, I think that we are currently in a dip. The major part of the dip occurred in 1982 as 1981 was the last year we had a Voyager encounter and a considerable amount of money was required in the MO&DA budget on the Voyager program in 1981. In 1982 and 1983, we didn't have those kinds of expenditures. So, there would be an expected drop in 1982, 1983, and 1984.

Mr. NELSON. What are you projecting for 1985? Using 1984 dollars, your present request is about $90 million. What do you project for 1985 and 1986 if you have that?

Dr. EDELSON. We would certainly like to have a healthy increase, Mr. Nelson. Frankly, I am not in a position today to discuss the specifics for future year budgets; but I will try.

We would like to increase particularly the research and analysis budget in order to maintain the healthy university support that we presently have. In the fiscal year 1985 budget, we will increase research and analysis by $5 or $10 million, if we possibly can.

You must understand, of course, that we have not put that budget together. The number that we do have this year is $45.5 million for research and analysis. It is important to look at research and analysis and MO&DA as a total; but the mission operations and data analysis tends to follow the missions. So, there is a lot of operations in there; however the research and analysis budget is our pure research base.

Mr. NELSON. Right. I would commend you if you kick it up $5 million, but if you kick it up $5 million you will only be back to where you were last year. You cut it $5 million this year. Why did you do that?

Dr. EDELSON. We didn't exactly cut it, Mr. Nelson. The $45.5 million that you see there is actually $10 million above our 1983 budget request.

Mr. NELSON. The 1983 research and analysis budget is $50 million.

Dr. EDELSON. The $50.3 million in fiscal year 1983 includes the congressional add-on. At the time, we were putting together the fiscal year 1984 budget, the fiscal year 1983 appropriations had not been determined. We didn't know that Congress would be so generous as to add money in there.

Mr. NELSON. When you came to us in the end of January with the budget you didn't know that Congress had given you $50.3 million for research and analysis?

Dr. EDELSON. We did know by that time, Mr. Chairman. But, pulling together, takes several months from beginning to actual submission at the end of January.

Mr. NELSON. You had to, yes.

Dr. EDELSON. First of all, we made sure we had flexibility to cover all of the ongoing activities that were so worrisome in the previous year. Our fiscal year 1984 request is enough to cover the Mars data analysis activities, the IRTF operations, and the operation of lunar curatorial facility, and Halley's Comet coinvestigators as well as the International Halley Watch, and the work being recommended by the SSEC in 1984.

Mr. NELSON. In 1983 your budget request for this particular part of the budget was a very low $35 million approximately, is that correct?

Dr. EDELSON. That is correct, sir.

Mr. NELSON. Why did you cut it that low? We restored—we didn't restore, we added another $15 million to the research and analysis. Looking back now with hindsight, what was your thinking at the time? Why cut it to $35 million?

Dr. EDELSON. Our thinking at the time was that fiscal restraints were very tight and we were trying to prepare a budget which was consistent with the President's economic recovery program. We had to cut out projects such as VOIR and the American ISPM spacecraft development and felt that we could and should reduce the research and analysis to be consistent with that.

We are now extremely happy that we will be able to continue the support of the Pioneers and the Voyagers, of course, and as I mentioned earlier, to continue operation of the lunar curatorial facility, operation of the IRTF and so on.

Mr. NELSON. I understand what you say your reasoning is. I am trying to point out an inconsistency however in NASA's position here. The budget was tight in 1983 but the budget is even tighter in 1984 and 1986 and you say you would like to kick that on up considerably in the future.

You are talking research and analysis. Can you explain that inconsistency of the thinking for fiscal 1983 versus fiscal 1985?

Dr. EDELSON. Mr. Nelson, I think we would like to restore the overall health of the program which has suffered to some extent by having missions delayed and rescoped and by clamping down on the research and analysis budget. Incidentally, we started a major study of the NASA-university relationships in space science, and we are concerned that any reduction in the R&A budget causes difficulties at the graduate student and postdoctoral level for a

number of the research institutes at the universities. So we are building that area up.

Mr. NELSON. And that is super-important, isn't it?

Dr. EDELSON. It is extremely important.

Mr. NELSON. Did you agree with the $35 million budget in 1983?

Dr. EDELSON. Well, Mr. Nelson, I wasn't here at the time. I can say truthfully that that happened before I came on board. But, I know from talking with my colleagues and my friends that that was a difficult transition for us. I must add we are very proud and pleased with the budget that we are proposing for fiscal year 1984. We have the first new start that we have had in planetary since 1978 with the Venus radar mapper and hope that the Congress will support that new start. We will have renewed interest in research programs in planetary science, and if the Venus radar mapper is supported that will be reason, too, to keep the research and analysis budget going. After all, research is for the future programs.

Mr. NELSON. Absolutely.

Dr. EDELSON. A year ago, when it looked like future programs were not going to be very plentiful, there was perhaps some reason to say well, maybe we should cut down on the university support and research because there are not going to be future planetary missions. Now, with the recommendations of the SSEC and with the VRM, we feel that it is essential to support the research and analysis program and we will do our best, Mr. Nelson, to do that.

Mr. NELSON. Mr. Chairman, I thank you. This is one of the budget items that I think OMB should not intimidate NASA in trying to cut back. Research and analysis and research and development is our f[illegible]. I encourage you in your upward trend here.

Dr. EDELSON. Thank you, sir.

Mr. NELSON. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you, Mr. Nelson.

I have a few questions. First, I would like to continue with the questioning which Mr. Mineta started on the space telescope. I would like to know whether—maybe you cannot tell us yet, if you cannot, tell us when you can—whether or not there will have to be additional funding over and above what we have in 1984 or what you propose to have in 1984 because of delays?

Dr. EDELSON. Mr. Chairman, we cannot answer that question yet but we have every reason to believe that the budget effect in fiscal years 1983 and 1984 will be manageable and that we will most likely be able to work within NASA's overall fiscal year 1984 budget request.

Mr. VOLKMER. Fine.

Dr. EDELSON. The main concern that we have about the delay and the main concern about finances and the budget is the effect of delaying to future years and that expenditures on space telescope development will continue much longer than planned.

Mr. VOLKMER. In other words, in the out-years we still may have additional funds over and above what you presently budgeted?

Dr. EDELSON. Yes. I expect that we will require additional funds in the out-years; but, we will be able to manage in 1983 and 1984.

Mr. VOLKMER. Part of the problem with the telescope is not only the technical aspects, which you discussed, but also problems with management, is that a problem?

Dr. EDELSON. I don't think it is possible, Mr. Chairman, to separate management and technical problems. If I were to describe the problem I would say it is one of management of technical activities. If it is as it appears to be largely a scheduling problem, difficulty in performing the calibration and tests on the mirror and OTA that are necessary in order to integrate them, then——

Mr. VOLKMER. From a layman's viewpoint, perhaps the time frame originally envisioned was smaller actually than was needed to do that type of testing and calibration?

Dr. EDELSON. Yes. That is right.

Mr. VOLKMER. Basically that is part of the problem?

Dr. EDELSON. Yes, we feel that the engineering and planning that went into the testing and actual integration, that is putting together all the parts of the telescope—the primary and secondary mirrors, the main ring and all the structures that go with it, and to aline it and calibrate it—that that particular work was not scheduled as well as it should have been.

Therefore, I would hesitate to make a distinction between management and technical problems. I think they are very much intimately intermingled

Mr. VOLKMER. Those are the things you are working on?

Dr. EDELSON. Yes, sir.

Mr. VOLKMER. Now to get to a few things that concern me on Landsat. I understand that the thematic mapper is not operating at the present time?

Dr. EDELSON. The transmission link, the so-called X-band transmitter operating at about 8 gigahertz, is not transmitting. The thematic mapper itself is working. There are two X-band transmitters onboard the spacecraft.

Mr. VOLKMER. Right.

Dr. EDELSON. We lost the use of one when we went through a transition from one control system to another on the spacecraft and so we just used the other system. Now, we have had that same experience again and we have lost the use of the other X-band transmitter. To the best of our knowledge, the radio equipment, the power tube, and other electronics are still working.

It is likely that we have a software problem. That requires a lot of testing on the ground. We don't want to jam the spacecraft with a lot of commands. So, we will do that testing on the spare unit which is on Landsat-D prime at Valley Forge at the General Electric plant. That particular spacecraft is going through some testing right now and we are trying to get it ready to do all of this analysis on. That will take a few days to arrange.

We have good reason to believe that the problem is amenable to a software solution but we don't know for sure. Let me point out that in any event, the multispectral scanner is working and it is transmitting to Earth because it uses an S-band transmitter. Furthermore, as soon as the TDRS spacecraft goes into orbit, even if the X-band direct-to-Earth's transmitters don't work, the so-called KU-band transmitters used to communicate with the TDRS will allow us to get thematic mapper images via the TDRS spacecraft. So, there is a problem, but there are ways to work around this particular one.

Mr. VOLKMER. What stations—assume we have to go through the tracking data system, TDRSS—what stations will that imaging go into?

Dr. EDELSON. The TDRSS data comes down at our central ground station at White Sands.

Mr. VOLKMER. And anybody else won't be able to pick it up?

Dr. EDELSON. That is correct. If the X-band transmitters are not working, then the only way to get thematic mapper images to the ground would be to transmit them via the TDRS satellite to White Sands, N. Mex., and then by communications satellites to Goddard, and onward to any other place that wants the data.

Mr. VOLKMER. OK.

Dr. EDELSON. In fact that is the normal high performance way of working for which this spacecraft was planned.

Mr. VOLKMER. But if you get the other systems working that won't be necessary? If you get the X-band?

Dr. EDELSON. We will still use that as the most efficient way of doing it.

Mr. VOLKMER. Once the TDRSS goes up, that is what you plan to use?

Dr. EDELSON. Yes, sir, so we can get global images. Right now, we can only get images when it is over the continental United States, or east or west coasts.

Mr. VOLKMER. All right.

Looking at the budget I see where AgRISTARS is being phased out in 1984 completely; is that correct?

Dr. EDELSON. Yes, Mr. Chairman, that is correct. NASA is phasing out its AgRISTARS activities.

Mr. VOLKMER. Now, basically who will pick up this program or will it be picked up? Or is it just dead altogether?

Dr. EDELSON. As you probably know, Mr. Chairman, it has been a joint program on the part of NASA, NOAA, and the Department of Agriculture.

Mr. VOLKMER. Right.

Dr. EDELSON. It has been running at approximately $30 million or so per year for 1980, 1981, 1982, and 1983. In 1983, for example, NASA will supply $15 million, NOAA $2.1 million, and USDA $12.6 million. So, the total funding to that program will be $29.7 million in fiscal year 1983. This has been an ongoing program where we work together with these other organizations, the purpose of which is to develop remote sensing techniques for the Department of Agriculture. The AgRISTARS developed remote sensing technologies was to address USDA information requirements in crop identification, mensuration and condition assessment, commodity production forecasts; soil moisture measurements; conservation practice, identification and assessment, and other related requirements.

Mr. VOLKMER. Right.

Dr. EDELSON. It is the administration's policy that the user agency, in this case Agriculture, should pay for this research and development and if they are requiring the technical expertise of another agency such as NASA or NOAA then Agriculture should pay for it.

Mr. VOLKMER. So if I want to find the budget now, the money for AgRISTARS, I look to the Agriculture budget?

Dr. EDELSON. That is correct, Mr. Chairman.

Mr. VOLKMER. All right.

Let's get back to Mr. Brown's question regarding ACTS.

We anticipate down the road an agreement between NASA and one manufacturer, is that correct?

Dr. EDELSON. Yes, Mr. Chairman.

Mr. VOLKMER. If everything goes well, where does it put that particular satellite manufacturer in relation to others 6 years down the line?

Dr. EDELSON. That particular manufacturer would have a great advantage because he would have developed and flown, with a certain degree of Government support, the next generation of advanced communications technology. It is for that reason that we hope to have a good competition, and we hope that we will get a reasonably low bid price, because of the interest that the winning manufacturer would have in the results.

I should point out that NASA has had, over the past few years, about a $40 million technology development program. Much of the technology that we expect to fly on the NASA payload is already under development and has been proved out to a certain extent. It is likely that the satellite manufacturer will subcontract with the very same technology development contracts that have been in the NASA program. Likely, but it is not essential.

Mr. VOLKMER. Right. Not necessarily.

Dr. EDELSON. But more than one manufacturer would benefit from this, of course, under that scenario. Also, we expect there may be a teaming arrangement between manufacturers of spacecraft and subsystems and carriers.

Mr. VOLKMER. Dr. Edelson, are you aware of any real or political opposition to parts of your life sciences program and the use of animals, and so on?

Dr. EDELSON. Yes, Mr. Chairman, we have been, over the past months, the target of some various groups concerned with animal health and protection, antivivisectionists, who have written to NASA, to Congressmen, and to others expressing concern about NASA's treatment of animals in our life science program.

Mr. VOLKMER. What action has NASA taken in regard to this, if any?

Dr. EDELSON. First of all we have always followed all of the health and safety standards that have been set forward for animal care. We have scrupulously avoided—and it is our official and stated policy—to avoid any inhumane or cruel treatment to animals of any kind.

Our plans generally involve flying healthy animals first without testing of any kind to make sure that they can survive the flight. We then do tests in the most humane and acceptable way. All of our treatment in our holding facilities and at our Ames Research Center where much of this work is done, is done in accordance with the procedures and rules laid down by the committee that determines what are acceptable procedures.

We are seeking certification of our facilities at Ames and we are trying to explain ourselves over and over again to the community

who is concerned about this. I think we can summarize it by saying, Mr. Chairman, that NASA is involved in a program for use of animals only where it is necessary to do research regarding the health and safety of the astronauts.

The way we do this research is in the most humane fashion possible and done strictly in accordance with all the rules laid down by NIH and others who are experts in this area. We have time and again met with, written to, and explained our position on this to those groups concerned.

Mr. VOLKMER. Thank you very much.

The gentleman from Florida, Mr. MacKay.

Mr. MACKAY. I have no questions, Mr. Chairman, thank you.

Mr. VOLKMER. Thank you.

We have no further questions then. Thank you very much, Dr. Edelson, and your colleagues.

Mr. CHANDLER. Mr. Chairman?

Mr. VOLKMER. Yes.

Mr. CHANDLER. Mr. Bateman asked if he could by unanimous consent offer written questions to be responded to for the record.

Mr. VOLKMER. If he can do it in the near future they can be submitted to Dr. Edelson and I am sure he will submit the answers for the record.

That will conclude our testimony then by Dr. Edelson. Thank you very much.

Dr. EDELSON. Thank you, Mr. Chairman.

Mr. VOLKMER. We will now proceed with General Allen.

Welcome to the committee, Dr. Allen. You have submitted a statement and that statement will be made a part of the record. You may review it or you may proceed however you wish.

[A biographical sketch of General Allen follows:]

DR. LEW ALLEN, JR.

Dr. Lew Allen, Jr. is a vice president of the California Institute of Technology and the director of Jet Propulsion Laboratory. He assumed his duties Oct. 1, 1982.

Dr. Allen retired June 30, 1982, as Air Force Chief of Staff and a member of the Joint Chiefs of Staff. In the Air Force he held the rank of general.

He was born Sept. 30, 1925, raised in Gainsville, TX and graduated from the U.S. Military Academy at West Point in 1946 with a bachelor of science degree and a commission as a second lieutenant. He served as a pilot in the Strategic Air Command until 1950 when he entered the University of Illinois. There he received a master of science degree in 1952 and a doctorate in physics in 1954. Dr. Allen was then assigned to the Atomic Energy Commission's Los Alamos Scientific Laboratory as a physicist.

From 1957 to 1961 he was assigned science adviser to the Physics Division of the Air Force Special Weapons Center. And in 1961 he was assigned to the Office of the Secretary of Defense, Space Technology Office, in the Directorate of Research and Engineering, Washington, D.C.

From June 1965 to February 1973, he was assigned to the Office of the Secretary of the Air Force where he served in both Los Angeles and Washington in duties relating to military space systems, and in June 1969 became director. In April 1971 he became director of special projects, with additional duty as deputy commander for satellite programs, Space and Missile Systems Organization.

After serving briefly in the Air Force Systems Command at Andrews Air Force Base, Md., he was appointed in March 1973 as deputy to the Director of Central Intelligence for the Intelligence Community in Washington, D.C. In August 1977 he was named commander of Air Force Systems Command.

General Allen served as the vice chief of staff, U.S. Air Force, from April 1978 until he assumed his duties as Air Force Chief of Staff in July 1978.

STATEMENT OF GEN. LEW ALLEN, DIRECTOR, JET PROPULSION LABORATORY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

General ALLEN. Fine, Mr. Chairman, with your permission, I will submit that statement for the record and will speak briefly to some highlights and address myself particularly to those questions which you mentioned in your letter.

Since there are some new members, let me take just a moment to review what JPL is and the legacy which affects it. We derived from the pre-World War II Guggenheim Aeronautical Laboratory of the California Institute of Technology. The director was Prof. Theodore Von Karmen, the distinguished aerodynamicist.

In World War II we conducted rocket research for the Army Air Corps, and then JPL, as it became known in 1944, conducted programs for the Army Ordnance Corps and did so until 1958. In that time, we developed JATO rocket units, a wartime activity, engineered the Corporal, the U.S. first tactical battlefield missile, and later the Lab developed a solid propellant missile, the Sergeant.

In 1958, Caltech and the U.S. Government agreed that we would be transferred to the newly formed NASA to be under NASA cognizance as a NASA center. So 25 years ago, JPL began its work for NASA and the first task that it did was associated with the fabrication and operation of the first successful U.S. satellite, the Explorer I. I might add that we just celebrated our 25th Anniversary a few weeks ago.

Since 1958, JPL has been NASA's center for planetary exploration. That effort has covered the first U.S. voyages to the Moon and inner planets, and missions to Mars, Jupiter, and Saturn. JPL grew with NASA until about 1963, when it reached about the size, in terms of manpower, that it is now. JPL is now a laboratory of about 4,000 very competent people who contribute to national interests in a number of ways with the unifying main theme that continues of planetary and space sciences. JPL continues as a national resource, a part of Caltech, and is a NASA center performing R&D under contract from NASA for planetary exploration as well as a broad program of science, technology, and applications.

As to the future of JPL, we have a clearer vision of what will occur than was possible 2 years ago or even last year when there was a good deal of confusion. NASA has made plans for a revitalized planetary program which is responsive to the scientific objectives of the Space Science Board, and the programmatic recommendations of the Solar System Exploration Committee. Those NASA plans permit JPL to plan for its future in a sound way. The foundation is now laid for maintaining a professional staff at levels that are only slightly less than they were during the peak years at JPL.

The number of people who work on NASA projects will decrease somewhat more in the future than they have in the past—I will give you those figures in just a moment—partly because the demands for in-house spacecraft development work will decrease as the Voyager and Galileo teams complete their work and because we plan to use industry capability to a greater extent.

To review that point more, beginning in the 1970's, the NASA effort at JPL began decreasing and energy research increased. By

fiscal year 1980, there was about 80 percent of the effort for NASA and about 20 percent for energy. By fiscal year 1983, about 73 percent of the work in manpower terms at JPL is NASA, about 17 percent is energy and about 10 percent is defense work.

For the future, we would project that by fiscal year 1987, we would still have roughly the same manpower base, a little less than the peak NASA years, about 66 percent of the work at JPL then being for NASA, about 8 percent of it being for energy, and about 26 percent of it being for defense activities. So, we will have seen a decrease of about 30 percent in NASA work at JPL, a decrease from the mid-1970's really in energy work from about 20 percent down to somewhat less than 10 percent; and an increase in defense work which will go up to a number which we have decided should remain less than 30 percent.

In that same period of time, there is always—that shift is not the same in dollars, that is, the NASA proportion in dollars remains somewhat higher, and the reason for that is the increased use of industrial capabilities. In addition, there have been some changes in the characterization of the NASA work at JPL in that we supplemented the planetary exploration activities, such as the very large projects like Voyager, with other space science and applications work with emphasis on experiments, primarily on spacecraft in the Earth's orbit. We will continue to contribute to these important science programs to exploit the shuttle as time goes on.

Although the Department of Energy work has decreased we feel that our contributions have been, and continue to be, significant. We have taken key space technology, knowledge and techniques, and developed practical alternative energy systems.

With regard to the defense work, NASA and Caltech have agreed that JPL can do up to 30 percent of its work in the national security area. That agreement recognizes that there can be significant benefits to the Nation by applying JPL experience, as it has been and will be in the future, derived from the NASA technology programs, to tasks that are of value to national security. With the constraints then that we have agreed to apply, that is, that Defense remain below 30 percent, JPL will remain with the characterization which it has had in the past, that is, a NASA laboratory whose unifying theme is space sciences and particularly planetary exploration, and a part of Caltech.

Mr. Chairman, I am very proud of what JPL has done in this period of time. JPL's performance has shown an ability to apply its considerable talents where the Nation judges the need for those talents to be. We don't seek work for the sake of the institution, but to apply the progress from NASA's research to problems of national concern.

This approach will enable us to maintain the focus of planetary exploration as a unifying activity of the lab, even at the reduced levels dictated by these constrained budgets.

We will retain our status as a NASA center. JPL and Caltech will take care that the tasks that we undertake in the defense area are appropriate to our institutional character and to our technological skills and that they are consistent with our status as part of Caltech. To do that, we must encourage interactions with the facul-

ty and students to preserve that quasi-academic atmosphere that is so important.

I would like to, with those words that describe a bit of how we have addressed the future, spend a couple minutes to give you a few examples of some of the work that we have underway and some of the success that I think has drawn my admiration for their work in the past and my determination to continue that standard of excellence for the future.

First of all, Voyager is on its way to Uranus after those very remarkable encounters at Jupiter and Saturn. Both Voyagers are working well. Voyager I is probing the interplanetary medium with instruments that reveal much about the interplanetary space, and it will proceed to the edge of the solar system—that is, the edge of the magnetic bubble where the solar wind dominates the interplanetary space and where we transition to interstellar space.

Voyager II will encounter Uranus in January 1986. I realize that the laws of Kepler are virtually immutable on this point. It, too, will proceed to interstellar space if it continues to work well.

These encounters are very challenging. There is the opportunity as Voyager passes Uranus to make observations which could have the same dramatic character that the observations of Jupiter and Saturn have had. We know less about Uranus but it is clearly a cloud covered planet whose atmosphere may well provide startling pictures and whose rings will be of great interest to study. Voyager will be nearly 2 billion miles from Earth at Uranus. Two-way communications will take 5.5 hours at Uranus.

Galileo is our most significant undertaking. It is on track for a 1986 launch. There have been changes that this committee is well aware of, in launch vehicles, that have certainly caused serious perturbations in that program. But with the decision that the Centaur will be the upper stage, the Galileo program has settled down. We are on track for that 1986 launch. The flight time is 30 months shorter so we will be at Jupiter quicker with the assistance of the Centaur upper stage. It will make detailed observations permitting us to exploit the great successes of Voyager over an extended time, and will, of course, include a probe through the atmosphere of Jupiter, deep within the planet down to the level of the most interesting clouds, and should be a very exciting experiment. Galileo will also make close encounters with the four Galilean satellites of Jupiter and less close encounters of other satellites of Jupiter.

The Venus radar mapper is a source of great excitement because it is a new start after a long dearth of new starts. It is proposed in the 1984 budget. It will be launched by the space shuttle in 1988. It has been descoped significantly from the VOIR mission to meet the intent of the guidance to do the program at substantially lower costs. I am very satisfied with what JPL did in that regard. They brought the costs down very substantially. They have retained the key scientific value of the experiment and I think it is going to be a very successful mission. We have certainly been advised by our NASA monitors that there will be a great deal of attention and pressure placed on us to bring that program in on the costs as we have said. I, therefore, reviewed it carefully to see if we are in a sound position to fully fulfill the commitments we have made and I can report that I am really very comfortable with it.

The decisions have been sound, the hardware is well understood, the studies have been progressing very well, the contractors were already selected on the basis of VOIR efforts. I have a great deal of confidence that we will do it just as we have said we will do it. That mission is very important. It will allow us to resolve many of the features of the Venusian surface in a way that will allow us to learn about the plate tectonics on Venus, the gross features of the planet that are of so much interest to so many scientists because they bear not only on understanding Venus but they bear also on the history of the Earth.

There has been discussion about the Infrared Astronomical Satellite (IRAS). I would like to say just a little more about that. I have a couple of viewgraphs. IRAS is performing very well. We measured the use rate of the liquid helium and that number is much lower than we had assumed it to be when we made measurements in the laboratory. The reason for that is that the measurements in the lab had to be made with a cooled cover, a cover also cooled with liquid helium, and we could not sort out the amount of heating lost to the cover and the amount being lost to thermal leaks from the detector array.

Fortunately our estimates were quite conservative and in fact the performance is very good. Right now we are estimating 320 days of life for IRAS based on the use rate of liquid helium that we see. That is particularly significant because we anticipate that to do the survey right we will need 6 months. So the extra time that is available is very, very valuable because it means we can go back and program the satellite to look carefully at those objects of interest that have arisen during the survey. Since we are looking at a region of spectrum in the sky that has never been looked at before in this detail, there will be, without question, extraordinarily interesting objects on which we will want to do a more careful exploration. We will now have the time to do that if the satellite continues operating as well as it is now.

If these charts are hard to see they are the same pictures that are on the New York Times front sheet this morning.

Figure 1 is an optical picture of the Magellanic clouds in the southern sky and represents the galaxy closest to us. It is one of great interest to astronomers because what one sees are areas of dust and gas clouds which obscures processes that are going on and are believed to be the very formation of stars from the very beginning. For the first time, we should be able to look into those clouds, measure the temperature of that dust and see through it to stellar objects that are within and learn about the actual formation of stars.

Figure 2 shows the very early results and they simply represent the kind of data when it is portrayed in a map, which is of that segment of the sky that I showed you blocked off which is roughly, as I recall, a degree by 5 or 10 arc minutes. The object on the right is what is known as the Tarantula and is a particularly interesting region of the Magellanic clouds. This shows the extent of that Tarantula in a way you cannot see optically. It shows the bright sources that are white within there. These data confirm that IRAS is viewing extended stellar objects in a way that is new and exciting.

Figure 3 shows a blowup of that object called the Tarantula which will be so fascinating to continue to examine.

Figure 4 shows the same data in a different way so you realize all these representations conceal a lot of good data. This shows the passes which we have simply plotted in a 3-D plot, and the response of each of the detectors as they cross over that region. So you see that there really is a lot of detail of that extended object, a lot of information there yet to understand. This is all done at about 100 microns wavelength, the earlier ones were at 60.

When we go to the pointing phase, which we are sure we will have substantial time to do, the sensitivity of the instrument is greatly increased because now these are done while the instrument is allowed to sweep the sky. In that period of time, we will point and focus on certain objects and gain much in their sensitivity.

I would like to shift to a different subject now. I am showing you things which you may well have seen before, but this is a representation of Landsat photography (Figure 5), where you see the oranges and yellows, of the Sahara Desert, a region remarkable for being absolutely featureless. One looks at it and it is extraordinarily flat, I think a golf ball would probably go 600 yards and a bowling ball would probably roll all the way down hill to Sudan. Underneath that blowing sand, the radar picture, shown in the middle, revealed ancient water courses which have been confirmed by a team of people including JPL people and people from the Egyptian scientific establishment. They dug underground and determined by core samples that those things exist. But they reveal that here in the very driest part of the world there was at one time and not all that long ago, there was clearly substantial water and one might presume substantial opportunities for life and civilization.

My JPL friend, Dr. Ilache brought me back two samples of human artifacts which have since been dated at about 40,000 years that were picked up from a region of the globe where today one would hardly guess that living things ever had existed.

Another interesting activity—I only show this to reveal what some of the very dramatic techniques are permitting—this is a picture [figure 6] obtained from SEASAT which carried a radio altimeter. Of course, they are very effective devices, but the interesting thing, this altimeter was used from SEASAT to measure the height of the ocean under the following kinds of amazing conditions.

First of all, the location of the satellite was determined—the ability to know where the satellite was—to a few inches in space with respect to the Earth. Then one was able to model and take out of the data the effects of waves and tides and look at the surface in order to determine those variations that are due to the fundamental geode of the Earth, that is where the ocean surface represents the gravity field caused by the mass which is below the surface of the ocean.

To my amazement, this map portrays data in the Pacific particularly, and shows the effects of the under-sea mountains on the Emperor Sea mountain chain and islands of Hawaii. The trenches and major features are showing up in variations on the height of the ocean.

Figure 7 shows the kind of detail that can come from data when one is looking in the region of New Zealand and Australia, which

happens to be a region where the surface observations of the ocean floor were not complete, and has allowed one to fill in, where those data were not complete, to understand substantially more about the structure of that ocean bottom in a way that was simply not in accord with the existing maps of the surface bottom.

So this kind of data is fascinating and is indicative of what techniques exist today. That is all I have in slides.

In conclusion, Mr. Chairman, what I would like to leave you with today is the conviction that there has been a period of transition at JPL, and JPL has made that transition in a way which we think is in the country's interest. We remain a competent, capable, enthusiastic national asset with my determination to keep it that way and continue to play a key role in NASA space exploration.

Thank you, Mr. Chairman, I will be available to answer any questions you may have.

[Figures 1–7 of General Allen's oral presentation, plus his prepared statement and answers to questions follow:]

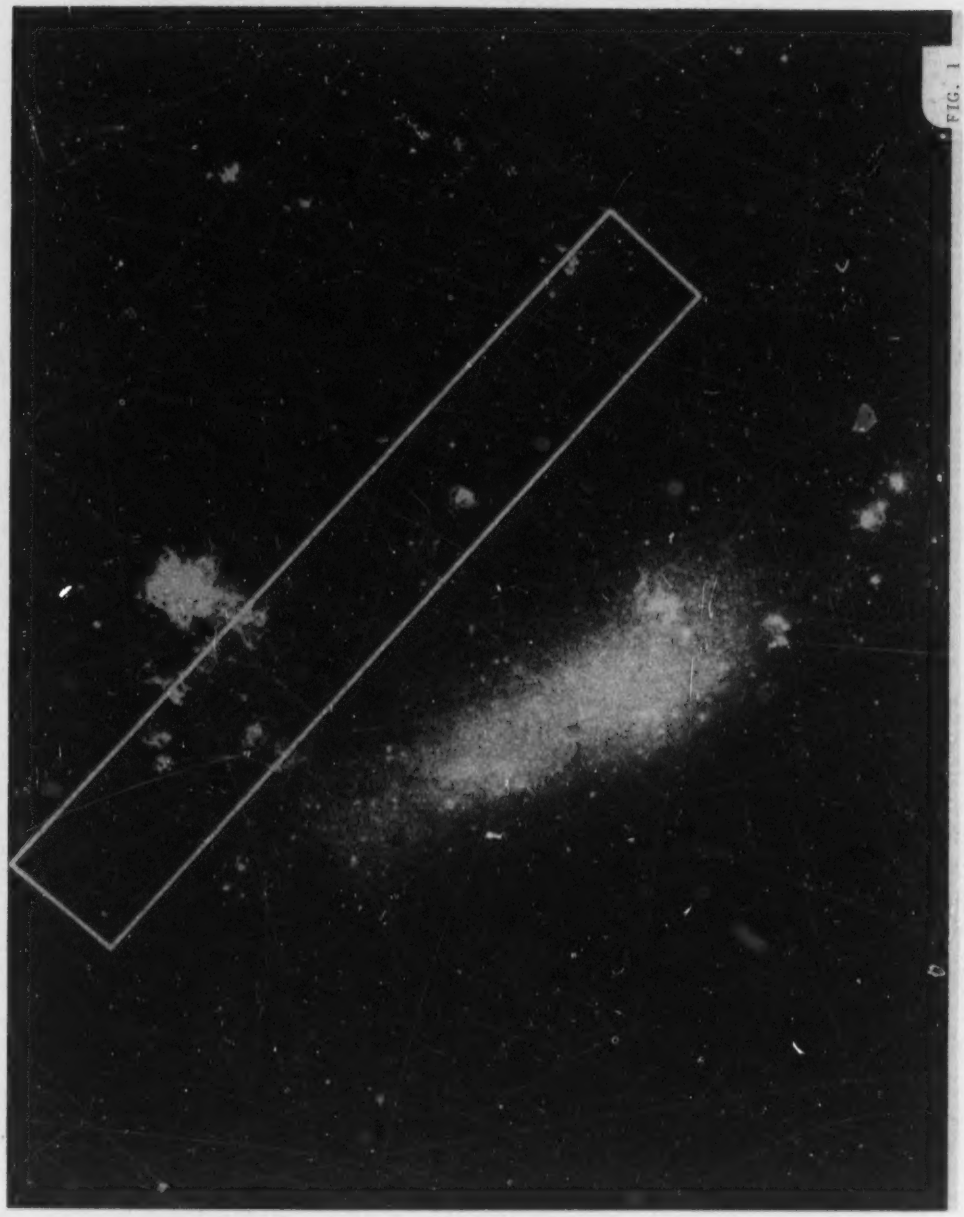

FIG. 1

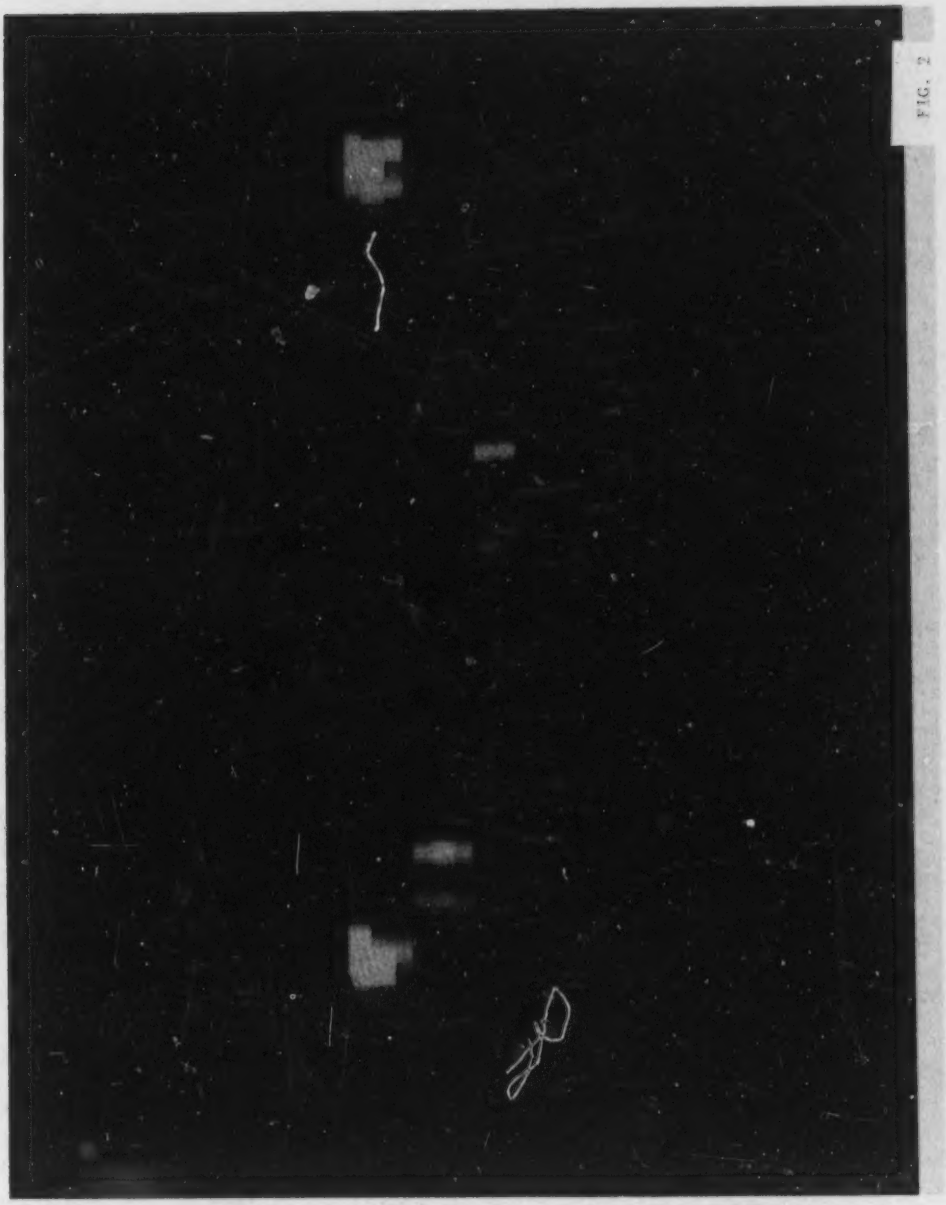

FIG. 2

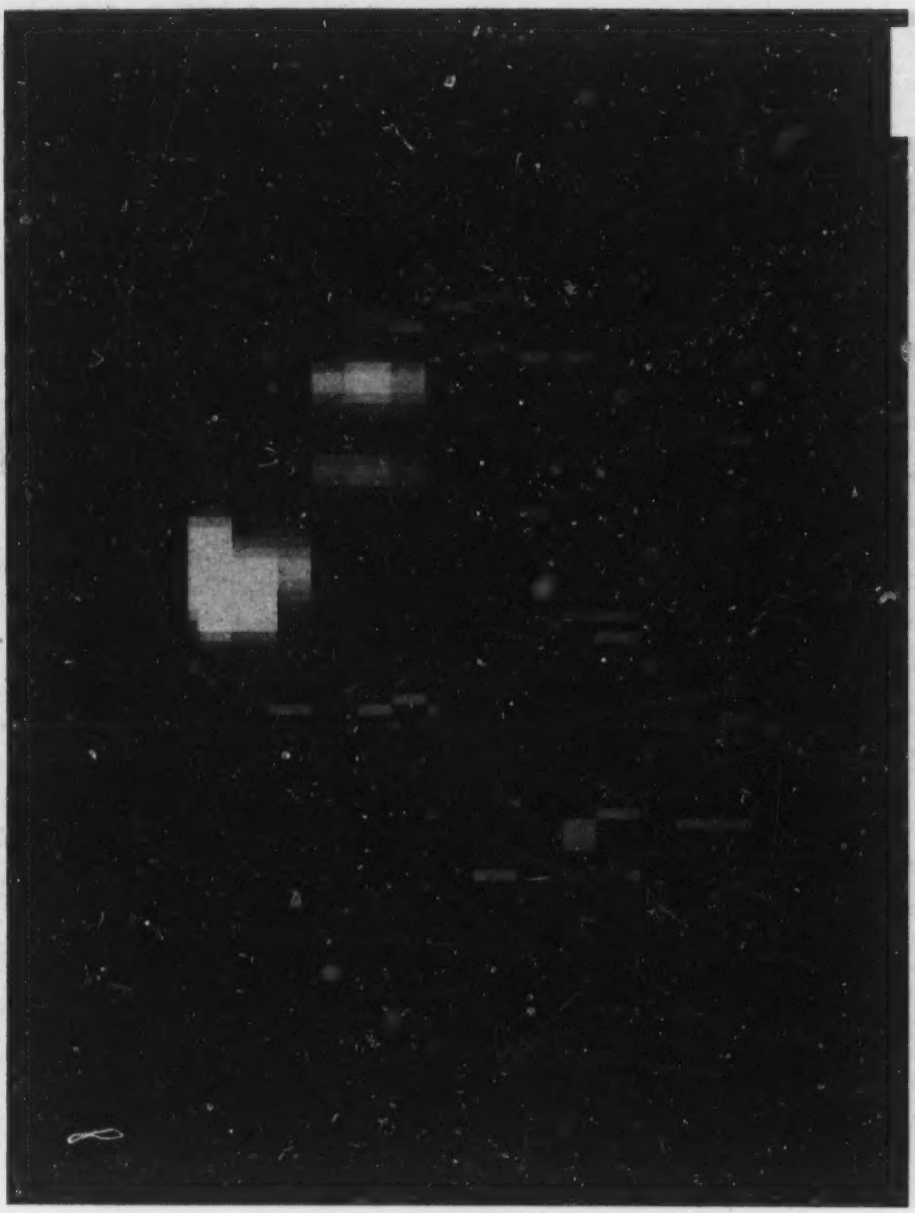

FIG. 3

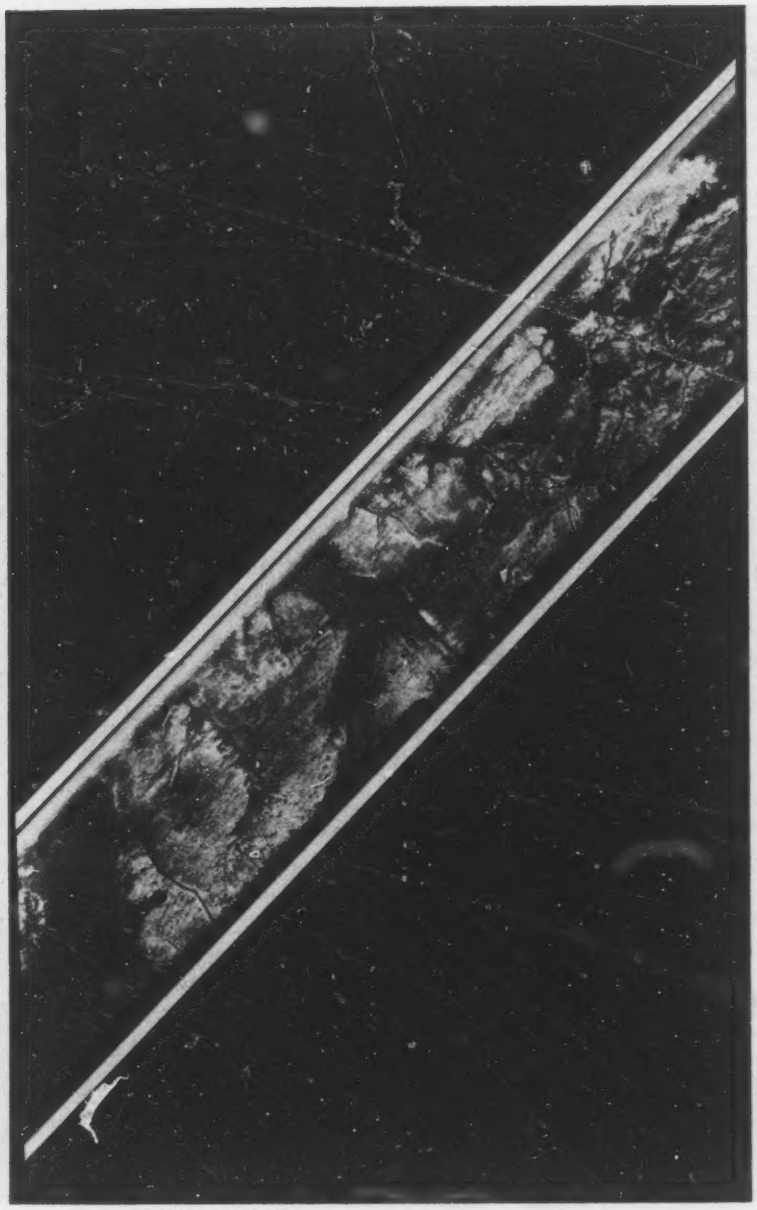

FIG. 5

Statement of

Dr. Lew Allen, Jr.
Director
Jet Propulsion Laboratory
California Institute of Technology

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

Thank you for your invitation to discuss with you my view of JPL and its future, and to highlight some of the major projects and activities of the Laboratory.

JPL and its parent, Caltech, are institutions with a heritage of accomplishment and a commitment to excellence. During the past two decades JPL has served as NASA's principal center for planetary exploration and has carried out other important space science and applications activities.

JPL undertakes difficult and challenging projects, and provides an exciting and stimulating intellectual environment for its staff. JPL is a national asset and its talents should be applied to tasks of national importance. They include space exploration, the use of space technology to better understand the Earth, energy resources development, and national security.

Last year Caltech and NASA decided that JPL should seek additional defense work, with the limitation that no more than 30% of the Lab's efforts would be directed to such efforts. The work will allow JPL to directly apply expertise developed for NASA and will help maintain and expand that expertise so that we can better serve all of our sponsors including NASA. The work we accept will be done with the same commitment to excellence, objectivity and integrity that has always characterized JPL work.

It is NASA's, Caltech's and JPL's full intent that JPL remain a NASA center, fulfilling the roles it has always played for NASA. The majority of our work will continue to be for NASA and we see no threat to fulfilling that intent.

Now I would like to touch briefly on some of the major JPL activities in the FY84 budget request.

In support of NASA's Planetary Program, JPL is continuing to explore the solar system with Voyager, Galileo, the International Solar Polar Mission and now the Venus Radar Mapper.

Voyager has completed its planetary encounters with Jupiter and Saturn. Both spacecraft are probing the plasma and charged-particle environments of the outer solar system. Voyager 2 will encounter Uranus and Neptune. The encounters should be

comparable in complexity and information return to the Jupiter and Saturn encounters.

Galileo is our mission to orbit Jupiter, study the four Galilean satellites in detail, and send an instrumented probe into the planet's atmosphere. JPL has overall responsibility for Galileo, is designing and building the orbiter, and will direct the flight. Ames Research Center is responsible for development of the probe, being built by Hughes Aircraft Company.

Excellent progress has been made since last summer to incorporate program changes brought about by the change to a Centaur upper stage. Although the launch date has slipped one year, until 1986, we will begin to get data a year earlier because the Centaur will cut flight time from four to two years.

1982 saw the initiation and virtual completion of systems-integration activities for the Probe with a large measure of success. We will complete Probe system testing later this year, and Hughes will deliver the Probe to JPL in December. A Probe drop test revealed a defect in the parachute design that has been corrected. The test will be repeated in July after wind-tunnel tests at Ames and Langley Research Centers.

System integration of the Orbiter is to start later this month and be completed this calendar year. After it is delivered, The Probe will be integrated with the Orbiter, and the combined system and environmental test program will start in the first quarter of 1984 and continue through the fiscal year.

The International Solar Polar Mission is a cooperative mission to investigate the polar regions of the Sun and the heliosphere outside the ecliptic plane. The European Space Agency is providing the spacecraft and five science instruments. JPL is managing the American portion of the mission, which includes development of five U.S. scientific instruments, mission design, tracking, flight operations, and data preparation and distribution.

Test units of the U.S. scientific instruments have been delivered, integrated with the spacecraft and thoroughly tested. Delivery of flight units of the instruments is nearly complete and testing of the entire flight spacecraft should begin in April. The testing will extend well into next year, then the instruments will be calibrated, refurbished, and stored until final preparations for launch begin in late 1985.

The Venus Radar Mapper has been proposed by NASA as a new start in Fiscal Year 1984. Launched by the Space Shuttle in 1988, it will arrive at Venus in August. In eight months it will map at least 70% of Venus' surface from orbit. The mission has received strong endorsements from NASA's Solar System Exploration Committee and from the Space Science Board of the National Academy of Sciences as the most important next step in exploring the terrestrial planets.

The Venus Radar Mapper will use a synthetic aperture radar to probe Venus' thick clouds and produce images of the planet's surface. Experience with Seasat and the Shuttle Imaging Radar (SIR-A) has shown us that SAR images are very useful for geological

investigation and can be interpreted with high accuracy.

The Venus Radar Mapper will cost about half the previous Venus Orbiting Imaging Radar mission. Many of the cost-saving features come from using an elliptical orbit at Venus. We can do that with the SAR because we recently developed new digital data-processing techniques. That allows roughly one-third of the spacecraft components to be flight-approved units left over from Voyager, Galileo and the International Solar Polar Mission. Another third uses existing designs, leaving only the final third as unique to the project. Using proven technology and an experienced team of industrial contractors and Laboratory personnel, we are confident of the project's cost and schedule.

Looking to the future of America's planetary program, the Solar System Exploration Committee of the NASA Advisory Council was chartered to translate the scientific strategy and priorities developed by the Space Science Board of the National Academy of Sciences, into a realistic sequence of missions that can be done within our budget contraints. Two years went into studying ways to fly lower-cost missions; they include restrained and better-defined science scope, greater use of spacecraft inheritance, and development of shared mission operations. SSEC concluded that a balanced core program of high-quality science missions of low to moderate cost can be carried out within a sustained funding level of about $300 million (FY84 dollars) a year. JPL has actively contributed to and participated in the studies. Although we have not yet seen the final official version of the SSEC recommendations, we fully expect to endorse enthusiastically those recommendations and, with NASA approval, to assist in carrying them out.

During the past year, the Laboratory has reviewed the overall architecture of the systems used in conducting flight operations and identified the changes necessary to enable lower-cost mission operations in the future. We intend to take advantage of the recently available, low-cost microcomputer systems and advances in automation to implement systems used in the Space Flight Operations Center.

JPL supports NASA's Physics and Astronomy Program with Earth-orbiting Explorer-class flight projects and with a major flight instrument, the Wide Field/Planetry Camera for the Space Telescope mission.

JPL was project manager for the Solar Mesosphere Explorer, an atmospheric-research satellite that studied how ozone concentrations form and move about in the atmosphere between 20 and 90 kilometers altitude. SME was launched in October 1981, and is in its second year of operations. Recently it studied the ash cloud in the stratosphere caused by the eruption of the Mexican volcano El Chichon.

The Infrared Astronomical Satellite was launched from the Western Space and Missile Center on Jan. 25, 1983. IRAS carries a cryogenically cooled infrared telescope in a near-polar orbit at an altitude of 900 kilometers (560 miles). The infrared sky survey started Feb. 10 and is proceeding on schedule. The

telescope's performance is exceeding expectations -- both in terms of sensitivity and the stability of the infrared detectors. We expect the mission lifetime to exceed the pre-launch estimates by a significant factor.

IRAS is contributing answers to such questions as the origin, constitution and replenishment of dust and gas between the stars and surrounding them, and formation of molecular clouds and stars. IRAS will also provide insight into the energy balance in ionized hydrogen regions, normal galaxies, extragalactic sources and quasistellar objects throughout the Milky Way galaxy.

Among the first results from IRAS is an image of the Tarantula nebula, in the southern sky near the Large Magellanic Cloud. The Tarantula is a vast collection of very cold dust and gas that radiates strongly in the infrared. The image was captured during the very early hours of the IRAS mission, just after the lens cover was ejected. The Tarantula is almost the first thing IRAS saw when its eye was opened. I'm sure we will have many more things to show you as IRAS continues.

The augmentation to the Explorer Program in the FY84 budget request will allow us to begin work on the Extreme Ultraviolet Explorer in 1984. The prime objective of that mission is to conduct a sky survey in extreme ultraviolet wavelengths (100 to 1,000 Angstroms). The mission complements IRAS, which is surveying the sky at the other end of the visible spectrum.

The University of California, Berkeley, will provide the extreme ultraviolet telescopes for the mission. The satellite will be launched by the Space Shuttle in late 1987.

The Wide Field/Planetary Camera is one of five instruments to fly in the Space Telescope. This advanced camera, designed and built by JPL and Caltech, uses charge-coupled devices to provide photographs that are mosaics of four 800 X 800 CCD's in each of the two cameras. When flown with the Space Telescope, the instrument will permit truly major improvements in astronomical observations. The activities at JPL are currently on schedule for delivery on July 5, 1983, to Goddard Space Flight Center for integration with the other instruments and with the Science Instrument Command and Data Handling System.

JPL is also carrying out science programs, emphasizing flight experiments, for both the Environment Observations and Solid Earth Observation programs.

The Atmospheric Trace Molecules Observed by Spectroscopy experiment, which will fly on the shuttle's Spacelab-3 in September 1984, is designed to obtain fundamental information related to the chemistry and physics of Earth's upper atmosphere. ATMOS will examine a range from the stratosphere, mesosphere and lower thermosphere, to determine the detailed compositional structure, and its global, seasonal and long-term variability. It will also study the way sunlight is absorbed at different levels in the atmosphere. Plans call for ATMOS to be flown on the Shuttle at approximately yearly intervals after its initial flight next year.

JPL also participates in the Upper Atmosphere Research Satellite experiments and mission definition program. A Microwave Limb Sounder is being developed that will measure chemicals in the Earth's atmosphere, including ozone and chlorine monoxide. An Active Cavity Radiometer will be flown on UARS to monitor solar radiance and its variability.

JPL is participating in a potential NASA initiative on global habitability -- currently in the planning stage -- intended to be a major research effort to understand physical, chemical and biological changes on a global scale that affect the habitability of the Earth. It will make extensive use of satellite observations as well as NASA's highly developed information processing capability. The initiative will involve observations of the land, the ocean and the atmosphere, as well as the interactions between all three.

JPL is the leading NASA installation for ocean science. The JPL-developed Scanning Multichannel Microwave Radiometer that was launched on the Seasat and Nimbus 7 satellites made simultaneous measurements of surface temperature, wind speed, columnar water vapor and cloud liquid water over the oceans. Analysis of data from the instruments has provided new information on the variability of those parameters on a global basis as they affect oceanography and climate.

Analysis of the variations of sea-surface height measured by the Seasat altimeter in repeat orbits provided the first detailed spatial profiles of mesoscale variability (wavelengths from 100 to 1,000 kilometers) of the global oceans. The measurements provide an important step toward improving our ability to model the ocean circulation.

Satellite altimeter readings of the ocean surface have been processed to create a topographic map of the global ocean floor. The false-color map shows details on the ocean surface that reveal previously unknown features on the ocean floor, especially in the poorly surveyed southern oceans. The Louisville Ridge southeast of New Zealand, which existing bathymetric charts show as a discontinuous chain of seamounts, is now confirmed to be a continuous chain. Northeast of the Louisville Ridge is a large plateau nearly the size of California that appears much larger than previously suspected.

The Ocean Topography Experiment (TOPEX) is a potential future mission under study to map the circulation of the world's oceans from detailed altimetric measurements of the sea surface. TOPEX could be launched in the late 1980s. Its altimeter would measure height variations on the ocean surface, which can reveal details of currents, eddies and other features of ocean circulation, in addition to sea-floor geologic structure.

The Pilot Ocean Data System is being developed by JPL to demonstrate techniques for management and analysis of large amounts of oceanographic data from satellites.

In support of the Solid Earth Observation Program, JPL has several experiments planned for the Shuttle/Spacelab payloads.

They include the Shuttle Imaging Radar-B, a follow-up experiment to SIR-A that was flown on the Space Shuttle in 1981, and will fly on the 17th Shuttle mission in the summer of 1984. SIR-B will provide data for a variety of geologic, oceanographic and land-use studies including cartography, geomorphology, forest monitoring and hydrology. Unlike previous spaceborne imaging radars, SIR-B will have a movable antenna that can look at targets from different angles.

JPL's Shuttle Multispectral Infrared Radiometer, carried on the Shuttle in November 1981, located a previously unprospected area that is potentially rich in ore deposits in a remote Mexican desert. A team of JPL and Mexican government scientists investigated the area in 1982 and verified that the area is a prospective mineral deposit. The finding marks the first time a suite of minerals typical of metal-rich areas has been discovered from space. Initial geochemical analysis on samples collected at the site show high values for molybdenum and silver.

A Lab-developed Imaging Spectrometer is a remote sensing instrument aimed at the generation of Earth remote-sensing instrumentation that will follow the Landsat program. The principal feature of the imaging spectrometer concept is high spectral resolution, with images acquired simultaneously in more than 100 spectral bands, allowing direct identification of many minerals as well as assessment of vegetation types and their state of health. A working model, the Shuttle Imaging Spectrometer-A, will be used to evaluate the technology and experiment concepts.

The Deep Space Network supports planetary and interplanetary flight projects using its three main deep-space communications and tracking facilities near Goldstone, California; Canberra, Australia; and Madrid, Spain. The DSN is controlled from JPL.

In preparing for critical navigation requirements of Voyager and Galileo, the DSN used a technique known as Very Long Baseline Interferometry to measure the angular position of Voyager in space to within three-millionths of a degree -- equivalent to reading a Los Angeles freeway sign from here in Washington.

In 1984, under the Networks Consolidation Program, one link of the Ground Spaceflight Tracking and Data Network stations at Canberra, Madrid and Goldstone will be transferred to the DSN. The consolidation of the NASA ground networks was initiated to effect operational economies after the Tracking and Data-Relay Satellite Systems becomes operational in supporting spacecraft in low orbit about Earth. In 1984, a major reconfiguration of the Goldstone facilities will be under way, the 26-meter antenna in Australia will have been relocated, and the 26-meter antenna in Spain will be in the process of relocation. This consolidation of network elements will provide savings in both facility and staffing costs associated with supporting the set of missions that are not supported by the TDRSS. Final consolidation will

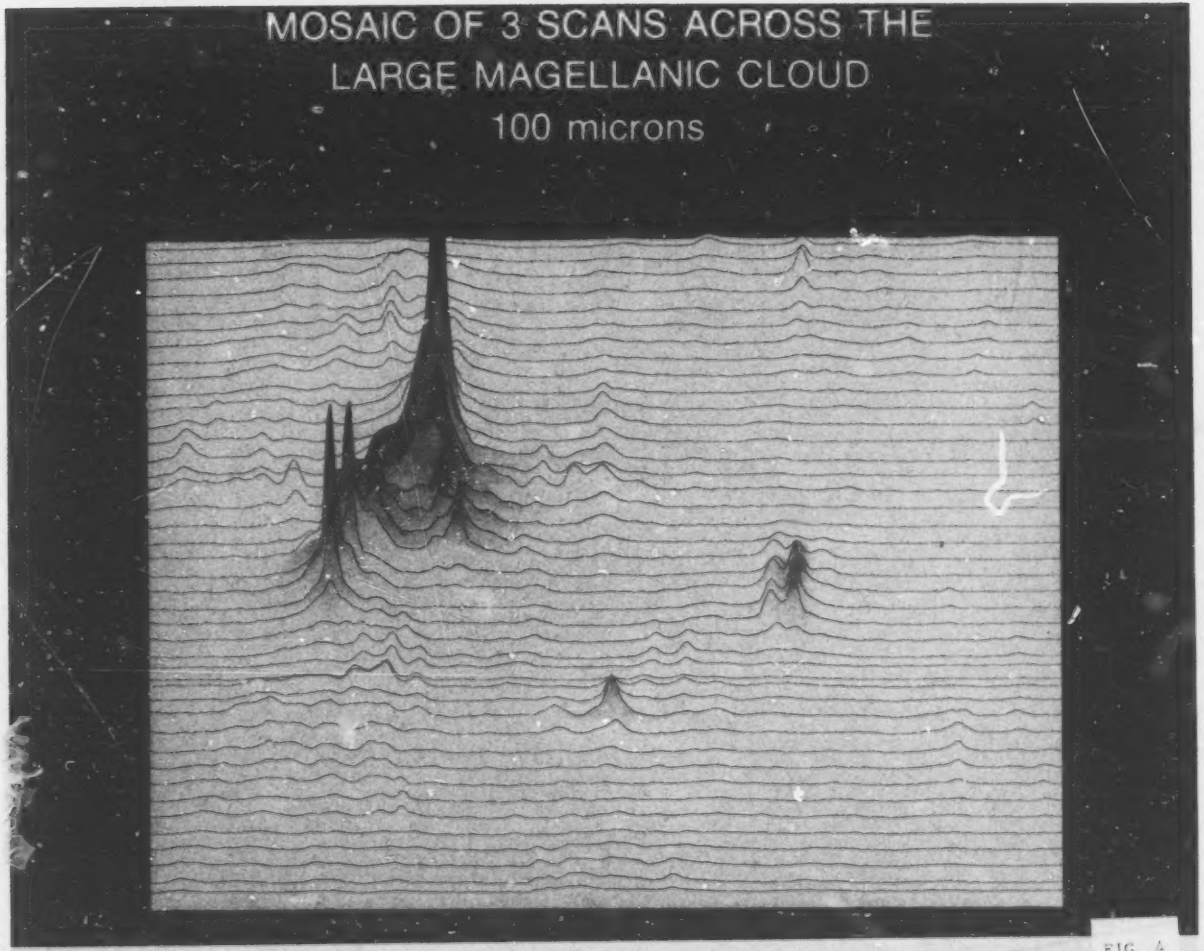
MOSAIC OF 3 SCANS ACROSS THE
LARGE MAGELLANIC CLOUD
100 microns

FIG. 4

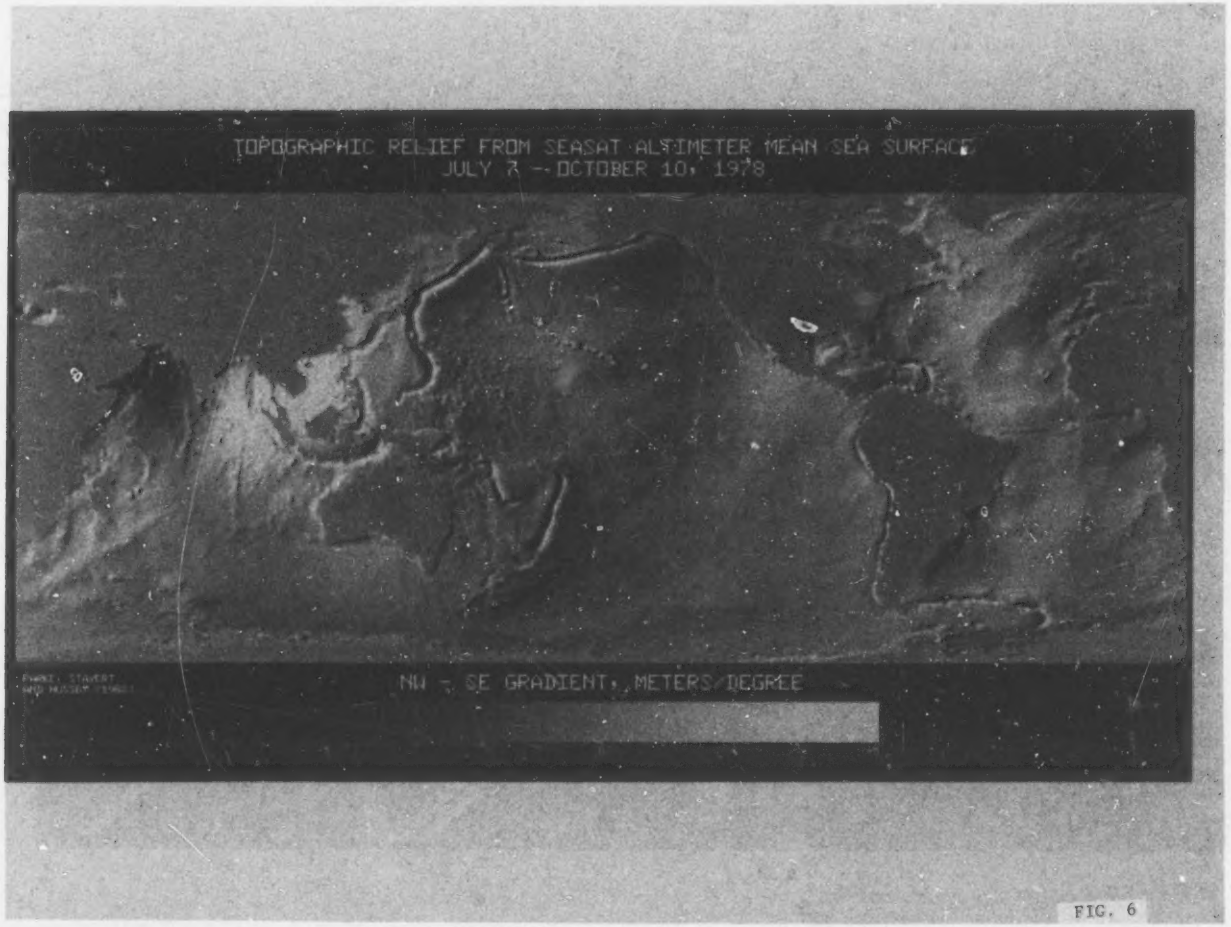
TOPOGRAPHIC RELIEF FROM SEASAT ALTIMETER MEAN SEA SURFACE
JULY 7 -- OCTOBER 10, 1978
NW - SE GRADIENT, METERS/DEGREE

FIG. 6

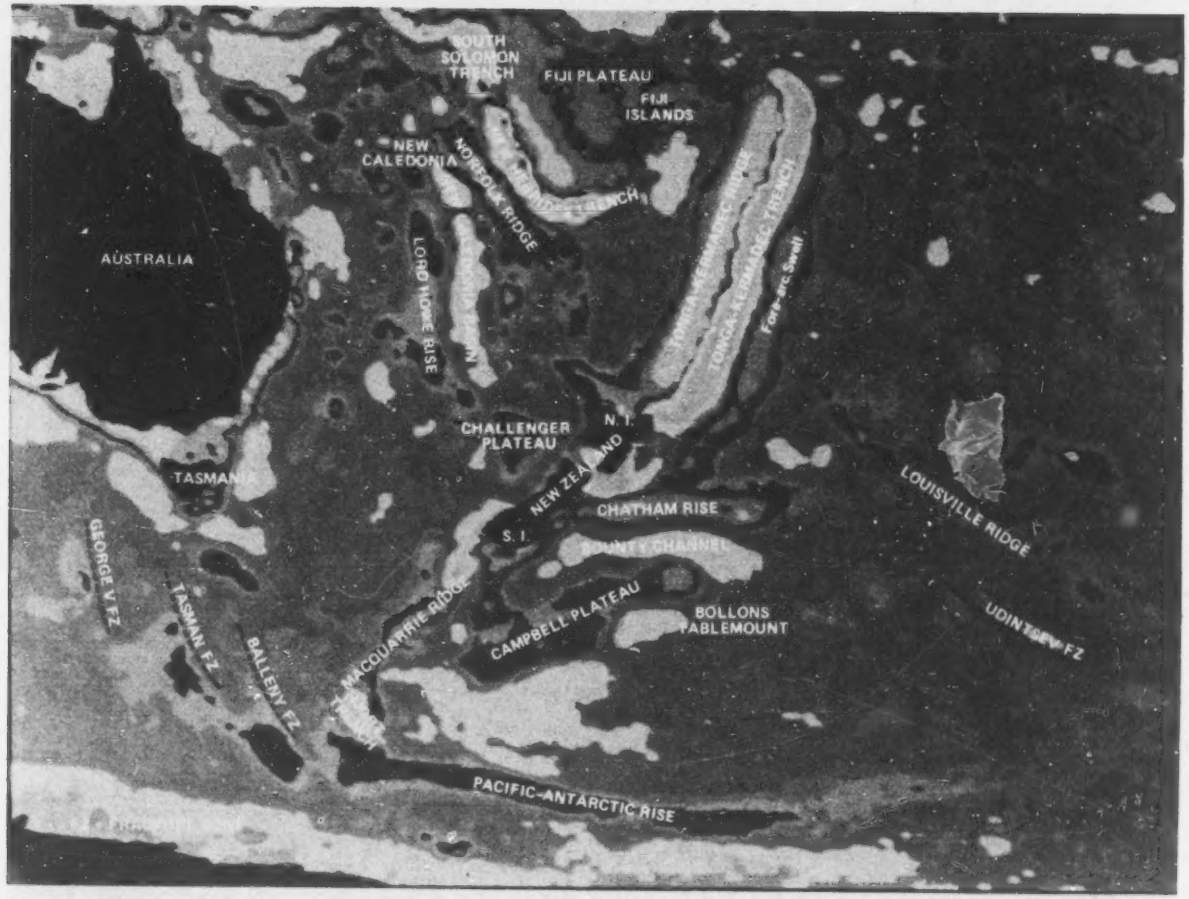
SOUTH SOLOMON TRENCH
FIJI PLATEAU
FIJI ISLANDS
NEW CALEDONIA
NORFOLK RIDGE
NORTH FIJI BASIN
AUSTRALIA
LORD HOWE RISE
TONGA-KERMADEC RIDGE
TONGA-KERMADEC TRENCH
Fore-arc Swell
CHALLENGER PLATEAU
N. I.
NEW ZEALAND
S. I.
TASMANIA
CHATHAM RISE
BOUNTY CHANNEL
LOUISVILLE RIDGE
GEORGE V FZ
TASMAN FZ
BALLENY FZ
MACQUARRIE RIDGE
CAMPBELL PLATEAU
BOLLONS TABLEMOUNT
PACIFIC-ANTARCTIC RISE

FIG. 7

not be complete until 1987. Progress in the Networks Consolidation Program continued through 1982 against a background of increasing requirements for support to additional flight projects.

Preparations for the encounter of Voyager at Uranus will continue through 1984. New 34-meter high-efficiency antennas will be completed at Australia and Goldstone to increase the amount of data returned. Plans were made in 1982 to further improve the telemetry performance by arranging for support from the Australian Commonwealth Industrial and Scientific Organization 64-meter radio telescope at the Parkes Observatory. Arraying the Voyager signals received at the Parkes facility with those received at the 64-meter and 34-meter antennas at the Canberra Deep Space Communications Complex increases the potential for picture return by 20 to 50 percent.

By 1984, the DSN will be increasingly involved with support to the international missions to Halley's Comet which are planned by Japan and the European Space Agency. Those missions, the MST-5 and Planet A from Japan, and Giotto from ESA, will be the DSN's first reimbursible missions. The DSN will also support the International Sun-Earth Explorer 3 mission, which will encounter the comet Giacobini-Zinner in September 1985.

The DSN will be supporting the Active Magnetospheric Particle Trace Explorers which will be launched in 1984, a joint international spacecraft mission involving the United States, West Germany and the United Kingdom. This will be the first of the highly elliptical Earth-orbiter missions to be supported by the DSN.

The Space Research and Technology Program at JPL is sponsored by NASA's Office of Aeronautics and Space Technology. It is organized by technical discipline with anticipated applications to the general categories of Space Transportation Systems, or Space Platform Systems. It also includes efforts for the development of generic technology that may be used in several applications areas. JPL has projects and tasks in most of the technical disciplines sponsored by OAST for space utilization.

One broad area of development involves autonomous systems, the design of spacecraft and the required subsystems that would be capable of operating independent of man's intervention for months and, we hope, years. JPL is also involved in design and application of robotic systems, teleoperator equipment, and in developing adaptive systems capable of making analytical decisions -- artificial intelligence.

In the communications field we are developing higher frequency equipment to support planetary missions. High frequency (X-band) will enable increased bandwidth with increased data rates, and allow us to use a less-crowded area of the radio-frequency spectrum. We are also involved in development of equipment to permit satellite communications to mobile vehicles.

For advanced spacecraft we are developing more efficient photovoltaic power systems, improved batteries and power management equipment, and antennas with electronically steered beams. The subsystem developments are focussed on particular requirements of new, low-cost multimission spacecraft.

We are performing studies and design analysis of large, controlled space structures. Those structures (an antenna, for example) will be as much as 10 to 100 meters in size and require precise shape control and pointing. The design tradeoffs between communication performance, structural rigidity, and pointing require improved materials and improved pointing control system with multiple sensors and actuators.

We also support the scientific community in development of instruments and sensors. They range from laser sensors for atmospheric measurements to imaging sensors for Earth and space surveys.

In the aeronautics area, an experimental and analytical program is being conducted to determine boundary-layer stability and the location of laminar turbulent transition points. Mathematical modeling and wind-tunnel experiments are being conducted. The objective is to increase the accuracy of drag calculations. A second area of research involves a flight experiment to determine if a microwave radiometer may be used to predict areas where clear air turbulence may be encountered.

In concluding my remarks on the NASA-sponsored activities at JPL, I would like to note that there are many other NASA program activities at the Laboratory, which time did not permit me to comment on.

Now I would like to return to the general subject of work carried out by the Laboratory for other federal agencies.

Part of JPL's unique character is that it has a fully integrated capability to conduct space projects. JPL's capability in the full spectrum of activities from mission conception through analysis of the returned information enables effective management of projects with unforgiving deadlines, limited budgets and high demands for performance. NASA has encouraged JPL to seek DOD work that complements its continuing NASA responsibilities, maintains its unique capabilities and enhances national security. The work will allow JPL to apply technical and project-management expertise developed for NASA to appropriate national-security tasks and will help maintain our unique spectrum of technical and management skills. I believe the expanded DOD program at JPL will be beneficial to NASA, DOD and the vitality of the institution.

For many years, JPL has supported other federal agencies' R&D efforts. An example is the continuing decade-long commitment by NASA and JPL to national energy programs in both solar and conventional energy sources. The activities conducted for DOE (and its predecessors) have led to significant technological advances that should enhance U.S. industry's competitiveness in the world. At the

same time, they have provided a stimulating variety of challenges to the staff.

The commitment to a long-term, expanded DOD program is consistent and compatible with Caltech's and NASA's desire that JPL continue as a NASA center and as a respected national technological resource whose talents are available to address important national needs, including space exploration and applications, national security and energy R&D.

In conclusion, Mr. Chairman, I thank you and the Subcommittee again for the opportunity to talk with you today. We are, and we plan to continue to be, an important part of the Nation's space program. We will continue to work together with NASA at the leading edge of exploration and advanced technology.

RESPONSES TO WRITTEN QUESTIONS SUBMITTED BY CHAIRMAN VOLKMER.

QUESTION E-1:

In December 1980 NASA increased its cost estimate for developing the Space Telescope to $725 - $775 million, which is still the current estimate. It included a reserve of $194.8 million. The estimated cost for known requirements to complete the telescope was $337.7 million. As additional requirements become firm, the reserves are reduced and the estimated cost for known requirements is increased. The status of the reserves and requirements are shown below. (All dollar amounts are in 1984 dollars.)

Status as of	Unencumbered reserves for development						
	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	TOTAL
	(millions)						
Dec. 1980	$0.3	$8.1	$21.2	$68.7	$44.2	$52.3	$194.8
July 1982	—	--	1.4	16.1	22.0	39.3	78.8
Currently							

Status as of	Estimated cost of known requirements to complete development					
	FY 81	FY 82	FY 83	FY 84	FY 85	TOTAL
	(millions)					
Dec. 1980	$111.2	$98.3	$68.4	$46.0	$13.8	$337.7
July 1982	—	a/ 3.7	120.2	66.4	22.7	213.0
Currently						

a/This is the estimated cost for August and September 1982 only.

a. What is the current amount of the Space Telescope reserves?

b. Between December 1980 and July 1982, NASA used reserves at a rate of about $5.86 million a month. If this rate were to continue, the reserves would be eliminated by August 1983. Based on this information, what confidence does NASA have that it can complete the development program within the current estimate of $775 million?

c. In both fiscal years 1981 and 1982, NASA deferred work which was scheduled to be done during those years to succeeding years because of funding problems. From December 1980 until July 1982, the cost of work scheduled to be done in fiscal year 1983 increased from $68.4 million to $120.2 million, an increase of 76 percent. What is the current estimated cost of known requirements for fiscal years 1983 thru program completion? What is the likelihood that work currently planned to be accomplished in fiscal year 1983 will have to be deferred until future years?

ANSWER E-1:

a. As of October 1982, there was $56 million of unencumbered reserve in the Space Telescope program. Since that

time, technical and management problems have caused NASA to reassess the Space Telescope program and its reserve status. We are currently reviewing a range of alternatives for rephasing the work to minimize the cost and schedule impact. As soon as our evaluation is complete, we will inform the committee of our proposed actions.

b. As might be expected in a program of this complexity, we are continuing to experience technical problems, particularly in the Optical Telescope Assembly development activities, which will most likely impact the scheduled launch commitment of the first half of 1985 and runout cost of $725-$775 million (FY 1983 dollars) for the Space Telescope.

c. As a result of the difficulties we have recently uncovered in the development of the Optical Telescope Assembly, there is a strong likelihood that we will not only revise the total cost of the program but we will also need to reprogram funding in FY 1983 and FY 1984 to meet the required needs of this project. We anticipate that additional funding will be obtained from existing NASA resources in FY 1983 and within the budget totals proposed in the FY 1984 budget.

QUESTION E-2:

The problem of work deferral, caused by cost growth combined with fiscal year funding constraints, is not unique to the Space Telescope program. A 1979 Congressional oversight report entitled "Space Shuttle Cost, Performance, and Schedule Review" prepared by the staff of the House Subcommittee on Space Science and Applications, Committee on Science and Technology, addressed this problem. That report points out that to meet the immediate fiscal constraints of the Shuttle program frequently required the deferral of work, drastic fluctuations in contractor and subcontractor manpower levels, and delays in material procurement which increased the program schedule and cost risk in future years. In addition, managerial attention was totally dominated by this problem to the extent that the managers were unable to assess the future cost and schedule impacts of their short term decisions. The subcommittee staff concluded that NASA and the Shuttle contractors had not developed the appropriate tools for implementing the "constraint management" technique. For example, they had not developed an accurate method for estimating the effects of work deferral and "roll-through"; nor had they been able to adequately project the program reserve requirements. The staff recommended that NASA, its contractors and subcontractors provide increased management emphasis at all levels in developing methods for assessing both the short and long term impact of "work deferral" and "roll-through" from one fiscal year to the next. The subcommittee staff report also recommended that NASA implement the recommendations of the "Budget Forecasting Review Team" (commonly referred to as the Day Report) as they relate to the financial reporting system.

a. Repeated underestimation of annual funding requirements indicates that sufficient attention has not been given by NASA

and its contractors to estimating the cost impact of anticipated changes to the contract. What actions has NASA taken to implement the findings and recommendations of the subcommittee staff report and the "Day" report?

b. Specifically, has NASA developed independent analytical approaches which can be used to forecast downstream work requirements arising from growths and changes as recommended in the "Day" report? Are these approaches being used on the Space Telescope program?

ANSWER E-2:

a. It is true that NASA has underestimated the annual funding requirements for Space Telescope development. Technical difficulties, coupled with a combination of overhead rate increases and hardware and management interface complexities, have resulted in cost growths, and schedule slips. Every effort has been made to accurately estimate the cost impact of changes to the major contracts. The deficiencies in cost estimation have been due primarily to unforeseen technical difficulty and subsequent cost growth by the Optical Telescope Assembly contractor. The following addresses Space Telescope actions, as recommended by the findings of the "Day" report:

1) The compounding effect of roll-through due to required changes, technical problems and contractor under-performance is recognized and taken into consideration in budget formulation. A system of project reserves is utilized in the Space Telescope project.

2) Timely submission of Engineering Change Proposals (ECP's) is considered in award fee evaluations.

3) Particular emphasis is placed on runout costs in obtaining contractor inputs specifically for Program Operating Plan (POP) formulation.

4) It is agreed that 533 reports alone are not adequate for budget forecasting. Quality of the contractor's estimates is considered in budget forecasting as well as in award fee evaluations.

5) Assessments are made of contractor inputs and changes or additions made where judged necessary.

b. Independent analysis and parametric cost prediction techniques have been employed by NASA for quite some time. These techniques have been utilized during previous cost reviews of the Space Telescope Development program (December 1979 and December 1980), and they are also used during the annual Space Telescope budget formulation process.

However, these techniques are not absolute forecasters of future cost, as they rely on analogies with past programs in establishing baseline criteria from which to develop schedule and cost risk, therefore, cannot predict the extent of the technical complexity which may be encountered.

QUESTION E-3:

The Space Telescope Project Office uses an "earned-value" system to measure the ability of its two prime contractors to control costs and schedules. This system requires the contractor to plan, in detail, work to be performed and to establish a time-based schedule and budget for this work. Each month, the contractor reports the amount of work scheduled for that period and the funds budgeted for the work scheduled. The contractor then compares the amount of work scheduled with the amount actually performed. The result is a schedule variance (expressed in dollars). A negative variance means that the contractor accomplished less work than planned for that period. The report also compares the funds budgeted for the work performed with the actual costs for that work. The result of this comparison is a cost variance. A negative cost variance means that there was cost growth for the work performed during that period.

a. Analyses of the contractors' monthly performance reports through July 1982 show that the Optical Telescope Assembly contractor had experienced cost growth in 33 of the 45 months for which data was available and the Support System Module contractor had experienced cost growth in 35 of the 51 months for which data was available. Given this trend, isn't it likely that these contractors will continue to experience cost growth? Is this trend taken into account when performing risk analyses to determine if unencumbered reserves are sufficient to complete the program within the current development estimate?

b. What has been the total amount of cost growth (non-fee bearing cost) in the two contracts to date?

c. What action has the project office taken to control cost growth in these contracts?

d. Both the Defense Contract Audit Agency and NASA Headquarters have expressed concern over the amount of time Marshall Space Flight Center takes to negotiate changes in the contract scope, particularly for the Optical Telescope Assembly contract. The estimated cost of the added effort may change several times in the interval from the time the contractor submits a change request until the cost of the change is finally negotiated. However, it is important to negotiate the costs of these changes as soon as possible since after the costs are negotiated any increase in the cost of this work would be cost growth and therefore non-fee bearing. What have been the primary causes of delays in negotiating costs for these changes? What actions have been taken to reduce this time?

ANSWER E-3:

a. It is likely that the contractors will continue to experience some cost growth. The inability to accurately project costs because of unknown technical complexities is one of the factors used in establishing a reserve budget for the program. The development difficulties recently uncovered in the Optical Telescope Assembly program are prompting a reevaluation of our

reserve posture. Preliminary results make it clear that the existing reserve will not be sufficient to complete the program and reprogramming of additional funding within the totals proposed in the President's FY 1984 budget will be necessary.

b. Negotiated cost growths to date are $45 million in the Support System Module (SSM) contract and $38 million in the Optical Telescope Assembly (OTA) contract. Unnegotiated cost growth in the Support Systems Module (SSM) contract is estimated to be $17 million, plus $7 million for implementation of Government Cost Accounting Standard 41B. A review is currently being conducted to determine the extent of the Space Telescope technical difficulties so that a determination of the amount of additional cost growth in these two contracts can be made.

c. One of the major contributors to cost growth in these contracts has been the inability of the contractors to accurately project the amount of work required because of unforeseen technical complexities. Therefore, additional emphasis on planning and scheduling adequacy is being implemented.

d. Most of the increases in the Optical Telescope Assembly (OTA) contract have been due to overrun or constructive changes not requiring change orders. The inclusion of numerous claims for which the contractor requests fee for work that the Government regards as overrun has delayed evaluation and negotiation. Increased effort is being applied to evaluation of proposed changes.

QUESTION E-4:

Unlike the Department of Defense, NASA does not include the costs of its civil service personnel in the Research and Development budget for its individual programs. Instead, these costs are included in the Agency's "Research and Program Management" budget. Since this highly skilled work force contributes significantly to the accomplishment of the programs, it is important to review the two budgets together in order to understand the status of the program. Since the inception of the Space Telescope program, several efforts which were originally planned to be accomplished by the development contractors are now planned to be accomplished in-house by the civil service work force. In a sense, this represents a cost growth in the program.

a. Please provide a listing of all tasks which were originally planned to be accomplished by the contractors but were subsequently deleted from the contracts and are now being accomplished in-house.

b. What is the estimated value of this work?

ANSWER E-4:

a. Following are tasks that were originally planned to be performed by the associate contractors that are now being performed in-house, or by other contractors under the direction of the project:

- OTA Fracture Mechanics Analyses (In-House)
- Design and Development of Installation Equipment for Scientific Instruments and Fine Guidance Sensors (Design In-House, Mfg. Contractor)
- OTA Shipping Container Design and Development (Contractor)
- Space Support Equipment Design and Development (Design In-House, Mfg. Contractor)
- ST Simulator for ST Operations Control Center Training (In-House)
- Orbital Verification Planning (In-House)

b. The estimated value of this work is approximately $40 million, including costs of material and subcontracted effort.

QUESTION E-5:

When the Space Telescope program was revised in late 1980, the program was descoped to a higher risk program. For example, spares which would have been available to replace components which fail during the assembly and verification phase were eliminated from the program. In addition, a number of subsystem tests were deleted.

a. Please provide a listing of effort descoped in the late 1980 rebaselining.

b. How would NASA characterize the additional program risk associated with the descoping?

c. Since spares were deleted, how will the Agency respond to a component or subsystem failure which occurs during the final assembly and verification phase? If a failure should occur, will it mean that the Space Telescope launch will be delayed more than would have been necessary if the spares originally planned had been available?

d. How much money did NASA save by deleting the spares?

e. Does the reduction in subsystem testing mean that the overall Space Telescope test program is more risky?

ANSWER E-5:

a. Significant effort descoped in the 1980 rebaselining included reduction of orbital replacement units, reduction of spares, deletion of "1 G" crew systems equipment and tests, "safemode" software reduction, and reduction of a number of subsystem and black box level environmental and functional tests. The expected performance of Space Telescope should not be adversely affected by this descoping effort.

b. The descoping effort summarized above will impact our ability to respond to equipment failure during subsystem and system level verification and testing. For example, if during this testing we experience an anomaly in a black box for which we have no flight spare, we will be forced to repair the box rather

than replace it with the spare. This may add time to our test schedules. In order to minimize the impact of possible failures, we have retained flight spares for some of the most critical equipment and we feel that the additional risk introduced by this reduction in our spares program is acceptable.

c. Spares for many components and subsystems have been maintained, especially for those items such as rate gyros, reaction wheels, and batteries, which would require long lead time to repair or replace in a timely fashion. Complete replacement parts, assembled to the electronic board level, exist for many other components and subsystems. If a failure should occur for these components and subsystems, it will probably require more time and effort to correct than if a completely assembled spare were available. In most instances, however, workarounds and test procedure adjustments can be instituted to minimize or prevent significant delay in the Space Telescope launch schedule.

d. The reduction in our sparing approach was primarily accomplished by going from box to card level spares. This is estimated to have saved approximately $1.5 million.

e. A major purpose of subsystem testing is to weed out hardware and software problems prior to system level testing. The deferral of testing from the subsystem to the system level means that some problems will surface later in the program. Consequently, the risk associated with reduced subsystem testing is the increased time and resources required to correct these problems during system level tests. In either case, the successful completion of system testing will provide confidence to proceed to the launch.

QUESTION E-6:

One of the primary features of the Space Telescope program has always been the fact that it is capable of being repaired in orbit. In fact, it will be the first satellite specifically designed for in-orbit repair. Astronauts operating from the Space Shuttle will be able to remove failed components or subsystems and replace them, eliminating the need for a more costly return of the telescope to earth to repair a failed component or subsystem. This capability permits the agency to make fundamental alterations in satellite design. Whereas, in the past, it has been necessary to design satellites with components of an extremely high reliability and to frequently build in redundancy to preclude satellite failures, the unique capabilities of the Space Shuttle which enable in-orbit repair and, if necessary, the return of the telescope to earth, permit NASA to relax reliability and redundancy requirements.

a. To what extent has the Agency taken advantage of these unique Shuttle capabilities in designing the Space Telescope?

b. In 1980, prior to restructuring the Space Telescope program, the system integration contractor had identified over 100 components and subsystems as orbital replacement units (i.e.,

capable of being replaced in orbit). In order to reduce development funding, NASA reduced the number of orbital replacement units to about 21. What was the effect on future maintenance and refurbishment costs of such a drastic reduction in the number of orbital replacement units?

c. Are components, other than those designated as orbital replacement units, capable of being replaced in orbit?

ANSWER E-6:

a. The Agency has taken full advantage of the Shuttle's unique capabilities in the Space Telescope design and development. The Shuttle will be used to ferry the Space Telescope to orbit and to conduct in-orbit checkout prior to deployment. The Space Telescope is designed to be serviceable in orbit by space-suited astronauts during Shuttle revisits. In the event that a problem cannot be solved by in-orbit maintenance, the Space Telescope is designed to allow retrieval and return to earth by the Shuttle for ground maintenance and/or refurbishment and subsequent relaunch.

b. The effect is hard to ascertain quantitatively. We have retained 24 Orbital Replacement Units in the program. The most significant impact will be felt if one of the components which cannot be changed on orbit should fail and an adequate backup system does not exist on board. We have tried to minimize the possibility of such an occurrence by selecting as Orbital Replacement Units (ORU's) those components which are most likely to experience inflight failures and by providing some form of onboard redundancy for all other components. If this type of a failure occurs, a return of the Space Telescope to earth for ground maintenance or refurbishment will be necessitated, however, an estimate of the actual cost impact of such a repair cannot be determined with any level of accuracy at this time.

c. Components other than those designated as orbital replacement units are capable of being replaced in orbit. The maintenance and refurbishment planning includes testing in the neutral buoyancy tank to identify such components and to verify the crew procedures for on-orbit replacement.

QUESTION E-7:

Neither the cost to establish an operations capability for the Space Telescope nor the costs to operate the telescope during its lifetime are included as a separate line item in NASA's budget. Instead, these costs are a part of the Physics and Astronomy Missions and Operations line item in NASA's Research and Development Budget. In July 1982 Marshall Space Flight Center estimated that Space Telescope operations would cost $202.2 million (fiscal year 1984 dollars) through fiscal year 1988.

a. What portion of this estimate is nonrecurring, i.e., the costs to establish an operations capability?

b. In 1977, NASA estimated the base cost of recurring Space Telescope mission and science operations to be $10 - $15 million a year (fiscal year 1978 dollars). Has this estimate changed? If so, what is the current estimate?

ANSWER E-7:

a. The nonrecurring portion of the estimated Space Telescope Operations requirement through fiscal year 1988 is approximately 55 percent of the total estimate.

b. The recurring cost of Space Telescope mission and science operations is now projected to be approximately $30-35 million (FY 84 dollars) annually. This compares with the Fiscal Year 1978 estimate of $17-26 million (when adjusted to FY 1984 dollars). The difference is attributed to increased manpower requirements for operation of the Space Telescope Science Institute, including increased science support for general observers and archival researchers.

QUESTION E-8:

In addition to the development and operations costs, funding will be required for maintenance and refurbishment of the telescope. The current plan is to change out orbital replacement units after the first 2 1/2 years of operation; return the telescope for ground refurbishment after 5 years; change out orbital replacement units again after another 2 1/2 years; and return the telescope to earth for a major refurbishment after 10 years of operation. In July 1982 Marshall Space Flight Center estimated maintenance and refurbishment costs at $263.6 million (fiscal year 1984 dollars) through fiscal year 1988. Based on a launch date of mid-calendar year 1985, however, this estimate includes costs only through the first in-orbit change out of components. The first funding for the maintenance and refurbishment effort will be required in fiscal year 1984.

a. Where, in NASA's Research and Development budget, will the costs of maintenance and refurbishment for the Space Telescope be found?

b. What is the estimated total life-cycle cost for maintenance and refurbishment of the Space Telescope assuming a nominal 15-year life for the telescope?

ANSWER E-8:

a. The cost of maintenance and refurbishment of the Space Telescope can be found in the Physics and Astronomy Mission Operations and Data Analysis line of the budget request.

b. An orbital repair, ground maintenance, ground refurbishment budget scenario must be assumed to establish the life-cycle cost. However, in reality the actual costs for maintenance and refurbishment will be determined in part by future decisions such as when to initiate new instrument development, and what degradation should be allowed before

initiating Space Telescope repairs or maintenance. A nominal 15-year lifetime will require components and/or subsystem replacement. Orbital maintenance, using Space Shuttle capabilities, is the most cost effective method of assuring extended spacecraft life. In addition, return of the Space Telescope to earth for extensive maintenance or refurbishment should be considered in developing a 15-year lifetime scenario. The cost of replacing six scientific instruments is on the order of approximately $250 million. The additional refurbishment costs would depend on several factors, i.e., number of parts to be replaced with new components; number of parts to be repaired; replacement parts on hand versus those that may need to be manufactured; impact of Shuttle retrieval on Space Telescope hardware, etc. In addition, one would have to include Shuttle transportation costs.

QUESTION E-9:

When NASA revised the Space Telescope program in late 1980, the Agency established a target launch date of the first half of calendar year 1985. Internally, however, the project office established a goal of launching in November 1984. Contract schedules were structured to meet the November 1984 launch date. In effect, the overall launch schedule contained a 7-month reserve (November 1984 - June 1985). By August 1982, the project office had revised its launch goal to January 1985 because of continued technical problems and funding constraints.

a. What is the probability of meeting the Project Office goal of launching the Space Telescope in January 1985?

b. As of August 1982, the Optical Telescope Assembly contract specified delivery of that major assembly to the Space Telescope system integration contractor by December 1983. Contract incentives, however, permit the contractor to deliver the assembly as late as April 1984 and still collect a portion of the incentive fee. In addition, these incentives permit the contractor to deliver the Optical Telescope Assembly without certain subsystem such as the fine guidance electronics and still collect a portion of the incentive fee. What is the likelihood that the Optical Telescope Assembly will be completed and delivered by December 1983? What will be the impact on the launch schedule if this assembly is not delivered until April 1984? What will be the impact on the total system assembly, integration, and testing effort if the Optical Telescope Assembly is delivered without the fine guidance sensors/optical control subsystem and/or the fine guidance electronics?

c. Because of cost growth resulting from technical problems, NASA found it necessary to limit funding to the two development contractors in fiscal year 1982. As a result, the Support System Module contractor had to terminate manufacturing effort for a number of components. The "stop work" order for these components remained in effect for a number of months. The contractor reported that the revised manufacturing schedule was both inefficient and presented a significantly higher risk. How would NASA characterize the additional schedule risk resulting from the "stop work" order?

ANSWER E-9:

a. The difficulties encountered in the development of the Optical Telescope Assembly have caused the project office to abandon the goal of launching the Space Telescope in January of 1985. The project office is currently developing a number of alternatives to rephase the Space Telescope development efforts and to determine the impact on the launch schedule. As soon as our evaluation is complete, we will inform the committee.

b. Difficulties recently uncovered in the development of the Optical Telescope Assembly (OTA) make it clear that the OTA will not be delivered in December of 1983. Efforts are underway to establish a new delivery date. The launch date for the Space Telescope is closely tied to the delivery date of the OTA. Any delay in the OTA will cause the launch date of the Space Telescope to slip a corresponding amount of time.

The Fine Guidance Sensors, including the Optical Control Subsystem, and the Fine Guidance Electronics, are an intimate part of the Optical Telescope Assembly. There are no plans to deliver the Optical Telescope Assembly without at least one Fine Guidance Sensor (FGS) installed. Once one FGS has been integrated and tested with the rest of the system, installation of the remaining FGS's during total system assembly will not be a major disruption of the activities.

c. It was recognized that the slowdown of activities in FY 1982 and the shorter manufacturing spans in the Support System Module might result in less time to react to problems and, therefore, was an additional schedule risk. However, those elements which either entailed technical complexities and/or critical schedules were specifically excluded from the "STOP WORK" criteria. Manufacturing of the major structural components is underway once again and the work is progressing on schedule.

QUESTION E-10:

Achieving the pointing accuracy and stability necessary to realize the potential performance expected of the optical system has been described as the greatest remaining technical challenge in the program. The current requirement is for the telescope to achieve a pointing accuracy of .001 arc second radius and to maintain that accuracy to within .007 seconds of arc for a 24-hour period. NASA has described this requirement as analogous to focusing a telescope in Washington, D.C. on a dime suspended over Boston and never moving the focus outside the radius of the dime for 24-hours. This is certainly a technical challenge, a far more stringent requirement than has ever been achieved on any satellite to date, but nonetheless essential to realizing the potential of the telescope and justifying the large expenditures for this program. To date, contractors have determined that they will be unable to meet the requirement of maintaining a stability of .007 arc second and the requirement has been informally relaxed to .012 arc second.

a. What was the effect on achievement of the telescope's scientific objectives of relaxing the stability requirement from .007 arc second to .012 arc second?

b. In an effort to meet the relaxed stability requirement of .012 arc second, NASA directed the Support System Module contractor to shield the gyroscopes to block noise emanating from them and filtering into the guidance system. There is always a certain risk involved when a component with known and proven performance is modified; there could be a mistake in the modification and the component could be damaged or the modification could alter the interface between that component and other components and subsystems. NASA planned tests of the shielded gyroscope at Holliman Air Force base for late 1982. Have those component tests been completed? What were the results?

c. The ability of the telescope to achieve the stability requirement may be affected by a large number of different functions and phenomenon. For example, the responses of various parts of the structural system to any movement within the telescope can affect stability. Similarly, torques resulting from any component within the telescope which moves including, for example, the opening and closing of the apertures of the scientific instruments can affect the stability requirement. Given this enormous complexity, how does NASA intend to test the achievement of the accuracy and stability requirements? What level of confidence will NASA have at the time of launch that this requirement can be met? What will be the impact on scientific objectives if the requirement is not met?

ANSWER E-10:

a. The Space Telescope's stability requirement has not been relaxed from 0.007 arc seconds to 0.012 arc seconds. The stated scientific performance requirement is that 70 percent of the energy from a point source be encircled within 0.1 arc seconds. This can be achieved by an ST performance of .007 arc seconds pointing stability coupled with an optical quality of .075 wave front error (measured at 6328 A); or by a .012 arc seconds pointing stability coupled with a .05 wave front error. The OTA contract requirement is for .05 and at this time we see no reason why it will not be achieved. The contract requirement has not been relaxed. Current analyses indicate that a pointing stability of better than .008 arc seconds will be achieved.

b. The noise tests on four modified flight gyros were completed at Holliman Air Force Base in January 1983, and the test results are excellent. The measured noise levels were approximately two-thirds less than anticipated and approximately a factor of ten better than the specifications.

c. The overall pointing stability performance will be verified by analysis, supported by selected test results. A series of tests have been performed and others are planned, which will validate the analytical models. For example, tests have already been performed on the Support System Module (SSM)

reaction wheels and tape recorders, and the OTA Main Ring/Metering Truss Structure Assembly. A modal survey test is scheduled to validate the entire Space Telescope analytical model. The extensive analysis and testing that is being performed by NASA and its two major Space Telescope contractors will provide assurance prior to launch that the design will meet specifications.

QUESTION E-11:

The Space Telescope Science Working Group, an organization which represents the views of the scientific user community to the Space Telescope Project Manager, has described contamination control as the greatest issue in the spacecraft development, representing a large threat to both the observatory performance and the project budget. Even small amounts of contamination could degrade the ultraviolet properties of the telescope. The ultraviolet light gathering power of the Space Telescope is unique and has always been an essential feature of the observatory. Many of the scientific objectives of the telescope cannot be achieved if this capability is degraded significantly.

The contamination threat to the Space Telescope derives from two sources - particulate contamination and molecular contamination. Particulate contamination occurs when particles such as lint get into the light path of the optical components. Molecular contamination occurs when substances such as oils used in cutting and machining structural components evaporate after exposure to the temperature extremes of space and molecules of these substances redeposit on the optical surfaces. The threat from molecular contamination is by far the more serious of the two. In previous satellite telescope programs, molecular contamination was controlled by first cleaning all structural components with strong cleaning solvents and then "baking out" the components. During "bake-out", the remaining oils are evaporated before the structures are mated with optical components.

When the Space Telescope contracts were awarded, "bake-out" of structural components was not included as a requirement. Space Telescope structures are significantly larger than those of any previous orbiting telescope and only a few facilities in the United States are capable of performing a "bake-out" of components the size of those planned for the Space Telescope. The time required to perform the "bake-out" together with the equipment needed to clean the facilities and perform the "bake-out" would be very expensive. Since no data were available on the effects of not performing the "bake-outs", the contracts required only that the components be "visibly clean." Subsequent testing and analyses have shown, however, that meeting the "visibly clean" requirement will not be adequate. Molecular contamination would degrade Space Telescope optics to an unacceptable degree.

a. In October 1981, the Space Telescope Science Working Group established specific contamination control criteria which they said were essential to achieving the scientific objectives

of the telescope. Has NASA now accepted these criteria and incorporated them into the telescope development contracts?

b. What is the estimated cost and schedule impact of meeting the contamination control criteria established by the Science Working Group?

c. The Science Working Group has described its criteria as being consistent with the minimum performance requirements of the telescope. If NASA has not accepted the contamination control criteria established by the Science Working Group, what level of contamination control does the agency plan to require? What is the estimated cost and schedule impact of this requirement? What is the extent of performance loss which will result from not meeting the criteria established by the Science Working Group?

ANSWER E-11:

a. The Science Working Group contamination criteria were analyzed by a joint NASA/Lockheed Missile and Space Corporation/Perkin-Elmer technical review team to determine what steps must be taken by the Space Telescope Project. It was determined from this review that the major concern will be molecular contamination. It was also determined from this review that all large structural assemblies such as the Main Ring, Main Baffle, Secondary Mirror Assembly, Reaction Plate, Aft Shroud, Forward Shroud and Sun Shade must be "baked out," in a vacuum chamber, in order to meet the Working Group criteria. Additionally, clean room molecular contamination monitoring and procedural controls are needed to maintain hardware cleanliness.

All of the above hardware "bakeouts" and clean room improvements are currently being implemented. Remaining actions concerning the Focal Plane Structure and the Support System Module Equipment Section are presently under review. Tests and analyses are being conducted to determine whether or not bakeout of these items is required in addition to contamination control measures which have already been adopted.

b. The cost of the molecular contamination control program is estimated at $2.5 million with no projected schedule impact. Additional costs, to be determined, will be incurred if bakeout of the Focal Plane Structure and the SSM Equipment Section are required. Bakeout of the Focal Plane Structure, if required, will probably impact the OTA schedule.

c. The project has implemented the steps required to meet the Science Working Group criteria as stated above, and no additional performance loss is anticipated.

QUESTION E-12:

In order to maintain the precise alignment of optical elements necessary to achieve scientific objectives of the telescope even after exposure to the temperature extremes of space, NASA and its development contractors decided to build a number of structural components from graphite epoxy. The advantage of this material

is that it does not expand and contract when exposed to very high and very low temperatures.

The components attaching the focal plane structure to the main ring, for example, were designed from graphite epoxy, but the use of graphite epoxy caused a problem. The focal plane structure houses the science instruments and the primary mirror is mounted on the main ring. These elements must be kept in near perfect alignment to avoid any loss of light gathering capability. To avoid any change in alignment as a result of temperature changes, the components were built from graphite epoxy. Recent tests, however, have shown that these components, referred to as "flexure feet", probably would not be strong enough to withstand the stress or loads imposed during launch and landing of the Space Shuttle. Unless redesigned, the focal plane structure could break away from the rest of the telescope and present a hazard to the safety of the Shuttle and its crew. As of August 1982, NASA had identified several alternative designs to correct this problem but had not made a final decision on which of the designs to develop and test.

a. Has NASA resolved the potential safety problem associated with the focal plane flexure foot? What was the resolution?

b. What was the estimated cost and schedule impact of this design change?

c. Have the necessary tests been conducted to assure that the design change will provide adequate strength?

d. Since the focal plane flexure was originally designed with graphite epoxy in order to maintain the alignment necessary to achieve the telescope's scientific objectives, will the design change degrade that alignment?

ANSWER E-12:

a. The structural strength of the flexure foot has been increased to a satisfactory margin. This was accomplished through a modification which involved the installation of titanium "Boots" over the existing mounting feet which in turn are bolted to the flexure legs.

b. The estimated cost of $3 million includes Perkin-Elmer and subcontractor costs. Modification of the flexure foot was a significant technical problem. As a result, the Focal Plane Assembly schedule was impacted by about two months. This is a contributor to the current OTA schedule problems.

c. The strength tests have been conducted and the test results indicate that satisfactory margins exist.

d. The alignment stability of the graphite epoxy structure will remain within specification. The titanium "Boots" redistribute the load paths, but do not affect the alignment stability of the OTA and, therefore, do not degrade the scientific objectives.

QUESTION E-13:

The fabrication of latches to hold the scientific instruments in place has also been a particularly challenging effort for the Space Telescope Program. These latches are extremely complex: they must be strong enough to hold scientific instruments weighing up to 800 pounds in very close alignment even under the stresses imposed by launch and landing of the Space Shuttle; they must permit astronauts in orbit to detach and attach the instruments with ease; and they must avoid transmitting heat from the instruments to other structural components and thereby to the telescope mirrors. The latches are designed and built by the Optical Telescope Assembly contractor and furnished to the science instrument contractors. Delivery of some latches has slipped by as much as one year but at mid-August 1982, all but one set of the latches had been delivered. The one set of latches not yet delivered is for the wide field/planetary camera. Because this instrument is to be located on the axial rather than the radial plane, design of these latches is different. The ultimate tests to determine if the latches will meet strength and thermal conductivity requirements were to be conducted at the Marshall Space Flight Center late in calendar year 1982.

a. Have all scientific instrument latches, including axial plane latches, now been delivered? If not, what is the estimated cost and schedule impact of the currently planned delivery schedule?

b. Have all tests to demonstrate that the latches will meet strength and thermal conductivity requirements been completed? What were the results?

ANSWER E-13:

a. The Scientific Instrument latches have been delivered; however, some retrofitting will be required as a result of vibration tests currently underway. The impact of the retrofitting is currently under assessment. The Optical Telescope Assembly and Fine Guidance Sensor latches are not yet complete.

b. All static strength and thermal tests on the axial latches have been successfully completed. Galling of the latches occurred during vibration testing. A material modification to correct this problem is currently in progress and testing is to resume in March 1983. Strength tests and dynamic tests on the radial latches are planned for the second half of 1983.

Mr. VOLKMER. Thank you very much, General Allen.

Mr. Mineta.

Mr. MINETA. Thank you very much.

General, Dr. Allen, it is very good to have you in your role as Director of the JPL.

As you increase the level of work for the Department of Defense, do you anticipate that will have any disadvantages as far as JPL is concerned?

General ALLEN. It certainly has some. That is, the one thing that clearly has been of concern is that work for Defense tends to require security classification of both activity and some data. That is inconsistent with the academic atmosphere which we have attempted to have JPL provide and which fosters our role as a part of Caltech. So, it is necessary to be sure that we use appropriate care in selecting the projects which we do for Defense. We can certainly do classified work and we are doing classified work but it should not become so great or so onerous to our total activities that it would inhibit the scientific work which is the majority of our activity.

We have used that care so far. The 30-percent constraint which we have agreed to, I think, is another safeguard. With appropriate care, we can handle that all right.

Mr. MINETA. You have gone from 10 to 26 percent roughly?

General ALLEN. We are now at about 10 percent Defense work. We would anticipate over the next 5 years that number would grow. It cannot grow above 30 percent because that is what we have agreed.

It is only a slightly biased observation to say that JPL is so good that its talents are applicable to a lot of problems in the Government. So it is not so much a question of seeking work or of selling ourselves to Defense, it is a matter of saying, what, of these talents which have been derived from these NASA expenditures, is the best way for them to be applied?

Mr. MINETA. Is this sort of a prognosis that less moneys will be going into NASA, and that therefore, you had better look to DOD? Why did JPL/Caltech make this decision to go more toward Air Force or DOD work?

General ALLEN. Because of the reduction in the planetary program and the expectation that the continuing planetary program—which I believe is viable and is a sound program but which will be at a lower level than it was in the past.

Mr. MINETA. Is any of the work here for the Space Division of the Air Force?

General ALLEN. Yes, there is some work for Space Division.

Mr. MINETA. Would that be an increasing portion of the work?

General ALLEN. We do several tasks for Space Division in the nature of providing system engineering type support and technology support on several things. We are working with the view that in time one would identify a program of the sort that is in their space technology program at Space Division, where one will do prototype experiments or one of a kind, things where JPL could serve Space Division in a manner somewhat similar to the way it serves NASA.

We have not identified that role yet and it is turning out that most of the defense work underway is for the Army and tends to be in areas which are more associated with command and control and data processing.

Mr. MINETA. Thank you for that.

And that is compartmentalized, I would assume then, at JPL?

General ALLEN. You mean that the security——

Mr. MINETA. The work at JPL that you do for Space Division of the Air Force?

General ALLEN. I am not quite sure how to answer, but, let me say that it is my intention that the basic institutional character of the laboratory will not significantly change and that is that we will still work in the matrix system which you are familiar with, I think, which both JPL and AMES uses it. The significance of that is that it says our role is not to go off and be another agency for the Department of Defense but it is instead to be sure that we can effectively apply the progress and skills that come out of the NASA programs to problems which Defense has.

We can do that best if we can keep the technical disciplines moving across the fields and we do that well within our matrix organization. There has to be some segregation because of the classification of the work. In many of the projects we are doing, the end use is classified, some of the data which we have to use to define interfaces are classified but much of the actual work we do is not classified. That is fortunate when that occurs.

Mr. MINETA. My understanding is that you are constructing a frequency standards laboratory at JPL. Being a Californian I know that we have things that are called "earth tremors" every so often. Some people get very sensitive about earthquakes. I wonder, given the fact that we have rather frequent tremors, earthquakes, in California and more specifically in the Pasadena area because of the fault line, why was the decision made to have the lab located there?

General ALLEN. First of all it is a laboratory for frequency standards which means hydrogen masers associated with the deep space network primarily. Those are not sensitive to tremors; the controls that are required in the laboratory are perfectly adequate in a region that has the seismicity of Pasadena which really isn't all that bad by the way. It is more known for concerns about larger earthquakes in recent years than it is about the frequent tremors. So the laboratory is in a completely satisfactory location. We have investigated fully the conditions necessary to maintain the high standards that we wish in the laboratory to have and that is not made more difficult by seismic considerations. The building is, of course, built in accordance with the appropriate California and local regulations associated with earthquake strengths. So, we do not have any unusual concerns about that.

Mr. MINETA. As far as the work of the lab, does that not require vibration isolation of some nature?

General ALLEN. Not in any significant way, no. The hydrogen masers are not particularly sensitive to vibration. They tend to need an area which is free from the kind of vibration associated with trucks going by on the streets outside. You do worry about that. But the occasional tremor is not the kind of problem that you

have any serious concerns about. The normal sort of isolation mounts and all would be satisfactory. The location picked is up on the hill and away from truck and freeway traffic and it is very satisfactory as a location.

Mr. MINETA. So other than the adherence to the construction standards of the State law on earthquakes there has not been required any additional facilities or construction of a facility in a way to isolate it in some special way?

General ALLEN. No, sir.

Mr. MINETA. Thank you, Mr. Chairman.

Thank you, Dr. Allen.

Mr. VOLKMER. Thank you.

The gentleman from Kansas, Mr. Winn, do you have any questions?

Mr. WINN. Thank you very much, Mr. Chairman.

General Allen, has the fact that you have a military background caused any concern now that you have taken over at JPL? Particularly among the science types.

General ALLEN. There have been some people who wondered whether I was up to something funny. I am not.

Mr. WINN. Well, I have watched you work in several different capacities around the Hill and in other jobs that you had with the Government and in industry. I think you are doing a very, very, very, very good job.

General ALLEN. Thank you, sir. I am delighted to be at JPL. I should say that. I hoped my remarks would indicate that.

Mr. WINN. Your enthusiasm does, yes.

You mentioned that after the final testing the U.S. scientific instruments for the International Solar Polar Mission would be stored until 1985.

What is the delay for that launch? Why the delay?

General ALLEN. The International Solar Polar? I cannot give you the full history. I will provide it for the record if I may. That was where the United States canceled participation and decided to work with the Europeans and that is the schedule on which it is on. I suspect that what happened; but, I will confirm that. There was a schedule for delivery of instruments and we decided that the most efficient thing to do was to complete it in accordance with our schedule rather than delay it in accordance with the European satellite schedule, even though it wasn't needed until later.

I am convinced that that is the best schedule. By the way, the same will occur probably as far as we are concerned on space telescope, that is we are manufacturing the wide field planetary camera which is a very complicated part of the total structure. It is on schedule and we will try very hard to make sure that it stays on the present schedule even if the total telescope launch schedule slides some because we can complete our work more effectively if that is the case.

[The information follows:]

STORAGE CONSIDERATION FOR THE U.S. EXPERIMENTS ON ISPM

The original ISPM plan was to launch two spacecrafts, one provided by the National Aeronautics and Space Administration (NASA) and the other by the European Space Agency (ESA) in 1983. The science instruments were selected so that there

were some U.S. instruments and some European instruments on both spacecrafts. When the 1983 launch of ISPM was delayed to 1985, as a result of the FY 1981 amended Budget, and subsequently 1986, because of a switch of upper stages from the Inertial Upper Stage to the Centaur Upper Stage which required longer development time; therefore ESA decided to proceed with their spacecraft on almost their original schedule because it was the most cost effective option. Thus, the instruments for the ESA spacecraft, including those supplied by the U.S., were also maintained on their original schedule.

For the U.S. spacecraft and its complement of science instruments the budget required a delayed schedule. Subsequent events caused the cancellation of the U.S. spacecraft and its science complement; however, the ESA spacecraft development proceeded on plan.

The ESA plan is to complete the assembly, qualification and testing of the flight spacecraft and then mothball the spacecraft in Europe during 1983. For a variety of reasons, including the opportunity to further characterize and calibrate their instruments, almost all of the science investigators, including the European investigators, requested that their instruments be returned to their respective facilities during the storage period. ESA acquiesced to this request and the instruments will be returned to the experimentors at the end of 1983. They will be reintegrated with the spacecraft when it is taken out of storage for launch in May 1986.

Mr. WINN. I wish you would give us a complete breakdown on that.

General ALLEN. Yes, sir.

Mr. WINN. There is a lot of support and sympathy for the Solar Polar Mission in this committee and in Congress and I think we would like to have a complete breakdown on that for the record and some of the reasons for it.

General ALLEN. Yes, sir, I would be glad to do that.

Mr. WINN. I think I know this but could you give us some other sources of money for JPL?

General ALLEN. For all practical purposes, the only money that JPL receives is received through the NASA contract. We may assist the Sacramento Municipal Utility District under a separate contract but these are small things where there are specific tasks.

Mr. WINN. You do various experiments out there.

General ALLEN. Yes, sir. That money is transferred to NASA by either Energy, Defense, or FAA, in a couple cases. It is then applied to the NASA contract on a task order and then we perform our work on the basis of that task order.

Mr. WINN. OK. I wanted to clarify in my mind that other agencies, particularly that JPL did experimental work for DOE, and research work, and I didn't know if funds came from the agency or if it goes through NASA.

General ALLEN. Yes, the funding agency retains the technical authority over those tasks. NASA manages more intensely with some program than others. For example, as you know in previous years NASA and DOE were collaborators in much of the energy programs and, therefore, there was an intensive management content to the energy activities at NASA headquarters. That will decrease in the future.

Mr. WINN. One of the experiments I have seen out there was the experimental work done on new engines, automobile engines.

General ALLEN. Yes, sir, and we also worked on the hybrid and electric vehicles.

Mr. WINN. How are they doing with that and—was that DOE money?

General ALLEN. Yes, sir. It went fine as far as it went but again it is one of those activities in which we would anticipate that there would be some closeout activities but no new work initiated. The vehicle that went 75 miles was a part of that program. It was good engineering. A good base for picking that work up again is estimated.

When OPEC changes its present policies, of course.

Mr. WINN. Yes. I wonder if you might submit for the record, too, a breakdown of JPL's funding. What percentage of it is NASA, what percentage is military, what percentage is Caltech, what percentage is outside.

General ALLEN. I would be glad to do that. I can state it as far as 1983 numbers are concerned where we have a fair visibility in how that actually works. However, let me provide it for the record.

Mr. WINN. If you would, yes, because we are running a little late.

[The information follows:]

Estimates of percentages of fiscal year 1983 funding sources by agency for JPL are as follows:

	Costs (Dollars in millions)	Percent
NASA	$330	77
DOD	57	13
DOE	33	8
Other [1]	8	2
Total	428	100

[1] Other includes NOAA, FAA, NIH, Department of Agriculture, universities, Bureau of Engraving and Printing, and SERI.

Mr. WINN. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you, Mr. Winn.

The gentleman from Florida, Mr. Nelson.

Mr. NELSON. Thank you, Mr. Chairman.

First of all I want to ask that Dr. Edelson provide for the record with regard to my inquiries about 1985 and 1986, what we project to be mission operations and research and analysis in those years?

Mr. EDELSON. Be glad to.

Mr. NELSON. Thank you.

[The information follows:]

NASA has not developed the fiscal year 1985 and fiscal year 1986 budgets; however, our current planning, based on runout of President's 1984 budget request, assumes the following approximate amounts for Planetary Research and Analysis and Planetary Mission Operations and Data Analysis activities in fiscal year 1985 and fiscal year 1986:

[In millions of dollars]

	Fiscal year 1985	Fiscal year 1986
Planetary Research and analysis	45–50	50–55
Planetary Mission operations and data analysis	55–60	80–85

Mr. NELSON. General, I am an admirer of yours and have been for some time. I thought you were a tremendous Chief and you certainly are an example that even though we have a retirement system that gets some mighty high-powered folks out at a fairly early age, we do not lose you as a national asset.

General ALLEN. Thank you.

Mr. NELSON. I would like to take a different approach on a question I have to take advantage of your background as the Chief of the Air Force. One of the things that has been disturbing that has come out recently, for example, a couple weeks ago in Mr. Newman's testimony, is that the shuttle flight rate is dropping. For example, NASA has provided for us statistics to show that their December 1981 estimates for the shuttle launches from 1981 to 1987 were 72 and their most recent estimate now is for that same period only 69. It has dropped three missions.

The whole theory of the shuttle was to be competitive in the commercial world. If your flight rates are dropping it is going to be more costly per flight as opposed to the higher frequency of the flights driving down that cost per flight.

Do you detect any move in NASA that if this shuttle is not going to be competitive that this thing is going to be turned over to the Air Force?

General ALLEN. Well, Mr. Nelson, I am not really the most appropriate witness for that question.

Mr. NELSON. I understand that but you have been Chief of the Air Force.

General ALLEN. I have lost my Air Force hat and I am really a NASA contractor and not a NASA policymaker.

First of all the mission model—at least one of the reasons that it goes down with time, is that it is associated with the great technology success of satellite endeavors. On the military side, we used to launch satellites at a very high rate and they lived a short time, and performed their duties and then were replaced. At the present time, satellites perform those functions much, much better in much more complicated ways and live a very long time. So one of the results of enormous technological progress in competent satellites is that they don't need to be replaced so often and one sees, therefore, the launch rate go down.

Mr. NELSON. I understand you don't want to answer.

General ALLEN. I don't know how to testify on the Air Force. Certainly, the Air Force is interested in the shuttle for the military launches. Just in conjunction with the IRAS launch, I had an opportunity to review the status of construction at Vandenberg of the facilities and, of course, they are very impressive and represent a very major commitment to the use of the shuttle. The expendable launch vehicles are phasing out. We are all going to be relying on the shuttle very soon.

Mr. NELSON. Absolutely, and you know, there is another reason why we ought to have a fifth Orbiter. I don't want to pick on you, General, but I have to get my editorial comments in here.

Let me try this one. This is one that you can answer.

The combined release and radiation effects satellite is a joint NASA-Air Force cooperative satellite. We have heard that the Air Force has developed a low-cost fast implementation approach for

space science missions. What is your opinion about whether or not we ought to review NASA's and the Air Force's approaches? Shouldn't we—maybe together with the other appropriate committee, Armed Services—get together and review this?

General ALLEN. I think it would be an appropriate matter to review. The satellite program you mentioned, the CRRES is certainly a good example of where NASA and the services have joined together in order to do an effective program. As a matter of fact, I was reminded that the NRL was also a part of that. So it is a cooperation among several elements of Defense and NASA in order to bring this particular program off. It is a good example. The Air Force for many years—I have been involved in this probably for 20 years now—has had a program in which it attempted to use either piggyback opportunities or have some inexpensive launch opportunity provided in order to do a study program of technological high risk, one of a kind sort of things. And that goes on. It has had complications because of the changing status of launch vehicles and shifting opportunities for piggyback payloads but that is called the space technology program and it is, and remains to be an important part of Air Force activities. It is one where JPL thinks it can provide a role in assisting the Air Force in doing those things. It is certainly one where NASA and the Air Force can cooperate effectively.

I don't wish to comment on whether or how you wish to do that in the legislative process but I think you would find it a very interesting and productive area to examine.

Mr. NELSON. Thank you, Mr. Chairman.

Mr. VOLKMER. The gentleman from Florida, Mr. MacKay.

Mr. MACKAY. No questions, Mr. Chairman.

Mr. VOLKMER. The gentleman from New Mexico, Mr. Lujan.

Mr. LUJAN. Thank you, Mr. Chairman. I am sorry to be late. I was at another committee meeting on funding for the Nuclear Regulatory Commission. We just can't be two places at one time. I apologize for that, General.

On the space reactor, I have a question on the work between the Department of Energy, DARPA, and NASA. Could you tell me the role that NASA or JPL will play in that?

General ALLEN. There has been an agreement now signed. As you know, there was a well-advertized difficulty in reaching agreement among the three parties. But there was an agreement signed by Dr. Kerrebrock at NASA, and DOE and DARPA which established the roles and the responsibilities of the different agencies and so on.

JPL will be the system manager. We have been conducting competition in industry for those parts of the system that do not include the specific engineering details of the reactor, Los Alamos is the lab asssigned by DOE to work with us. Although this is really not even yet quite begun, it is shaping up as a fairly well organized, very long range, of course, but good project.

Mr. LUJAN. Do you consider that to be a development phase or still in the research phase?

General ALLEN. It is certainly premature to call it development in the sense that the designs are not at all settled. It is not clear whether it is thermionic or thermoelectric, for example. I think

there are even some who perhaps would propose rotating machinery for it. So many of the basic questions of how the reactor and power system are to be designed are not yet answered.

There have been designs made by some contractors which clearly lead one to believe they might be thinking they know how to do it, but it involves, first of all, a careful definition of what is required, what the numbers are that are appropriate to consider, what the rules are on how to proceed with it, and I think that what JPL will try to do is to identify in those specifications the ones which involve critical technology issues and insure that attention is focused on resolving those technology questions as quickly as possible and in an orderly way so the final decisions can be made for the system as the program continues.

Mr. LUJAN. Do you need new technology to be able to put it together or just the technology off the shelf? I am having a little difficulty expressing this. Perhaps it could be expressed better in terms of what we know about reactors, but making them much smaller. Do we have that knowledge so that it becomes an engineering problem, or is something completely new needed?

General ALLEN. I would like to give you perhaps a better answer for the record, but let me just briefly say this. First of all, there is not a mission for this power supply. Therefore, the final engineering and decisions that lead to the development are not really appropriate yet. One is trying to build the base of the supply and have confidence in it and then later if a mission application develops, one would go into real development.

With regard to what or where technology is needed, the only example that I can give is that when I asked my own people: "Is it clear that it is a thermionics conversion scheme?" The answer is "no." It isn't clear because there are engineering risks in a thermionic scheme that we are not quite sure that is appropriate to undertake. My understanding is that thermionics is probably the favored approach at the present time. Thermoelectric has less performance, but we would have a good deal more confidence in it, as I understand.

Those are issues that will be examined more carefully as we go ahead.

I think the situation is, that there are some time periods before us and there are opportunities to make significant advances at some risk and we will have to have a balance between the opportunity and whether one wants to undertake the risk in doing it.

[The information follows:]

Space reactors in this power range have not been developed. Heat transport and thermal-to-electric, conversion systems will require improved technology. For example, present thermoelectric couples are an order of magnitude too heavy for these applications and present Silicon-germanium materials for these couples operate at inappropriately low temperatures and below the desired performance.

Mr. LUJAN. Thank you, Mr. Chairman.

Mr. VOLKMER. I have just one question so that I might understand a little better. General Allen, I understand JPL is a contractor with NASA. What is your specific relationship to Caltech?

General ALLEN. We are part of Caltech. I am the director of JPL and vice president of Caltech. All of our employees are employees of Caltech.

Mr. VOLKMER. So, simultaneously they are on a teaching schedule as well as research schedule or mostly research?

General ALLEN. No, there are some joint appointments and there are a number of people at JPL who teach classes at Caltech. There are many professors at Caltech involved in activities at JPL as well as many students who do research at JPL. It is about 8 or 9 miles away and that is enough separation and yet a great deal of interchange occurs.

Mr. VOLKMER. As I understand, we have requested from NASA—and they have provided us with—a plan for a global resource information system, GRIS. How does the pilot ocean data system relate to GRIS?

General ALLEN. I think the pilot ocean data system, the pilot part of it means it is a demonstration, a system intended to examine the techniques of moving that data around to users and displaying it well. As such, it represents a very valuable precursor to whatever NASA wants to do in GRIS.

We are working on the pilot program to be sure it is done well. If I could digress a moment, one of the things that has a remarkable success in the infrared astronomical satellite has been the process of handling scientific data. The ground station is provided by the United Kingdom at Chilon, England, and they are responsible for software and reception of the data only at that station. The computation is involved in sending commands to the satellite for subsequent observations, also.

The totally unprocessed data from the satellite is shipped by means of a wide band data link into what we call the scientific data analysis system [SDAS] facility at JPL in Pasadena. There have been, as there always are in such programs, some uncertainties as to whether all the software is working here and there and until you get up into it, you don't know. Certainly, this one which was really the tail end and not under as much schedule pressure was the scientific data analysis system facility because it didn't have to be on line perfectly the first day. There was not as much confidence in SDAS for Day 1 as there was perhaps in other parts of the project. But in fact that system operated just magnificently. It has been producing data of the sort you have seen by taking the raw data from the satellite, converting to engineering units and portraying it in a way the experimenters ask for, shipping it back out to the investigators on the program in a manner where they can specify and essentially in real time.

So, they have done a remarkable job of analyzing, processing, converting, and shipping data out while the mission is in progress and that is in my opinion and in the opinion of those with more experience in this area really unprecedented. It is marvelous.

It is that type of thing that the pilot ocean data system would hope to do but on a broader range of data, in that there would be more sources of data that would come in and would require formating and direction. It is here that we believe we can make similar excellent progress. I think that will help address it.

Mr. VOLKMER. Thank you very much. If there are no further questions, that will conclude the hearing for today. We will adjourn until 2 o'clock tomorrow afternoon in 2318.

[Whereupon, at 12:25 p.m., the subcommittee was adjourned to reconvene at 2 p.m., Wednesday, February 23, 1983.]

1984 NASA AUTHORIZATION

WEDNESDAY, FEBRUARY 23, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:05 p.m., in room 2318, Rayburn House Office Building, Hon. Harold L. Volkmer (chairman of the subcommittee) presiding.

Present: Representatives Volkmer, Nelson, Lujan, Lowery, Chandler, Bateman, and Walker.

Mr. NELSON [acting chairman]. Today we continue our hearings on Space Science and Applications with a panel of three very distinguished witnesses who will testify on space science programs. There are several areas of interest here. Of course we are extremely concerned about the looming overruns in space telescope. We are also concerned about the research and analysis budget. We want to make sure that the NASA budget—and it is a large amount of money—is being spent in the most effective support of space science. I hope our panel can help us with considerations such as these.

Our first witness will be Dr. Thomas M. Donahue representing the Space Science Board of the National Academy of Sciences.

Second, Dr. Noel W. Hinners will describe the report of the Solar System Exploration Committee which has made a major contribution in describing how a scientifically robust planetary program can be conducted on a relatively constrained budget.

Finally, Dr. S. M. Krimigis, representing the Space Science Working Group, will discuss NASA's budget from the point of view of the university research community.

We would like to thank you gentlemen for testifying and answering these questions in advance.

STATEMENT OF DR. THOMAS M. DONAHUE, CHAIRMAN, SPACE SCIENCE BOARD, NATIONAL ACADEMY OF SCIENCES

Dr. DONAHUE. Thank you Mr. Chairman. Thank you for giving me the opportunity to meet with you here today to discuss the health of the space science in the United States. I am pleased to be able to report on behalf of the Space Science Board that on the whole we are gratified by the level of support for space science expressed in the President's proposed fiscal year 1984 budget.

From a comparison of the fiscal year 1984 budget request with trends in previous fiscal year budgets and culminating with the fiscal year 1983 budget request, there is evidence that an important

shift has taken place in the administration's assessment of the importance of the space science program. I sincerely hope that what we are seeing in the fiscal year 1984 budget is the emergence of a period of stability in both a fiscal and programmatic sense. If that is the case, and it will take several years to confirm, we will finally have reached a point where together we can quietly assess the state of this national resource and lay the groundwork for its secure future. Unlike the situation in fiscal year 1983, there is balance among the major space science disciplines in the program; none are threatened with cancellation or eventual demise; major, ongoing development projects are funded adequately; a new start for the planetary program is requested, the contrast with the fiscal year 1983 request for the planetary program needs no emphasis from me; major study efforts to develop the queue for new start candidates are supported. I shall address the question of support for the baseline problems for research and analysis and for mission operations and data analysis for ongoing missions separately, for we have a continuing problem in some of these areas.

To say that the space science community is satisfied with this fiscal year 1984 budget request is an oversimplification and not altogether accurate, given what has happened to the field over the last half-dozen years. The economic imperatives that have constrained the level of overall activity and threatened some of the fields represented in space science have forced a serious discussion of the value to the Nation of doing science in space and raised the question of whether there existed a level at which the future of the field could not be reasonably assured or might not be worth maintaining. I trust that the debate is ended with this budget submission. I hope this committee and the Congress will see the budget in the same light so that we can begin the task of reconstituting and rebuilding the U.S. position in space science.

Let me turn now to some comments on the details of the fiscal year 1984 budget request and the items you raised in your letter of invitation. The request for an augmentation in the Explorer line item is in accordance with longstanding recommendations of the Space Science Board and its Committee on Space Astronomy and Astrophysics and Solar and Space Physics as well as those of the Astronomy Survey Committee chaired by Prof. George Field. Probably the most important effect of this augmentation will be to allow the agency to increase the frequency of flight opportunities in the Explorer program. If Space Science is suffering a malaise these days—as it is—this state is a consequence of a dramatic decrease in the rate at which space science missions have been launched during the past decade and are presently scheduled for launch. The delays associated with changing from expendable launch vehicles to those of the space transportation system are partly responsible for the retardation. Associated with the decrease in the rate of flight opportunities has also been a tendency for missions to grow more and more complex during the past decade. As opportunities for flight have decreased people have tended to hang more and more features on each precious mission as it becomes available. This has increased cost and decreased the number of missions that can fit under a budget envelope. The result has been the operation of an unfortunate feedback loop that has put us in the

fix in which we find ourselves. Unfortunately, this syndrome has also affected the Explorers, a program originally meant to provide us with a flexible, inexpensive means of getting into orbit with minimal delays. It is time to reverse this trend. If not, the impace on university and other groups that depend on flight missions for their existence will be great. This increase in the level of funding Explorers will allow us to design missions in a realistic price range so that an average frequency of the order of one flight per year can be achieved.

The decision to request a new start for the Venus radar mapper mission, VRM, is most gratifying. The Committee on Planetary and Lunar Exploration, called COMPLEX, of the Board has identified the high resolution mapping of the surface of Venus as the objective of the highest scientific priority for the study of that planet. The agency and the Jet Propulsion Laboratory are to be complimented for designing an imaginative, fresh approach to the problem of mapping Venus. With the soatial resolution promised by VRM we should be able to identify important surface tectonic features, such as shield volcanoes, that will give us important clues to the structure of the interior of Venus and the evolution of the planet. We should also be able to detect marine or surface water features, such as fossil river channels and seashores, if they exist, that will tell us something about the size of an ocean that may have covered Venus when it was a young planet and lead us to deeper insights into the origin and history of Venus' atmosphere.

While I am on the subject of planetary exploration, I may as well mention one weakness in the program outlined by the Office of Space Science and Applications—this is the level of support requested for research and analysis for planetary exploration. The amount requested is below the level appropriated by the Congress for 1983. And here I must take the opportunity warmly to commend the Congress for correcting an alarming cut in funding projected for planetary exploration and for physics and astronomy last year. The amount requested for fiscal 1984 is not sufficient to keep in existence research groups that will be needed to analyze the results NASA hopes to obtain in future planetary missions. I have not carried out the detailed analysis needed to state just how great the shortfall is. As a reasonable guide, I would suggest, as we suggested during this committee's hearings last year, that the level of support in fiscal year 1981, adjusted for inflation, would be adequate to maintain the R&A program in planetary exploration for the near term.

The prospects for the future in the NASA planetary program are certainly enhanced by the promulgation of the long awaited report by the Solar System Exploration Committee, SSEC, of the NASA Advisory Council chaired first by Dr. John Naugle and then by Dr. Noel Hinners, on my right. What that committee has done is to identify a new and affordable way for NASA to conduct missions to the planets that can be carried out by variations on existing Earth orbital spacecraft and by the new JPL series called mariner mark II spacecraft. I think that it is important to put the first type of mission on the same stable, relatively low-cost basis as the explorer satellites. Instituting a level of effort program will allow us to get out of the mode in which every planetary mission becomes an all

out effort of the voyager or Galileo class. The missions identified by SSEC, such as the mars geoscience climatyology orbiter and the comet rendezvous mission, all conform with the strategy for planetary exploration developed by the Board's Committee on Planetary and Lunar Exploration. Indeed SSEC carefully used COMPLEX reports as a guide and interacted carefully with COMPLEX during its work.

Let me turn now to a less positive development. We are all—Space Science Board and NASA—very concerned about the delays that have developed in the space telescope, ST, production schedule. The Board has been thoroughly briefed by NASA concerning this problem. We are watching carefully. Our concern is to minimize the damage that may be done to the overall space science program as a result of the additional cost resulting from delay in completion and launch of the space telescope. It is important that the space telescope, when it is finally flown, be an instrument capable of performing uD to the expectations we all have for it. Given the forced relaxation in the telescope delivery schedule there is an opportunity to do more thorough testing and to perfect some of the telescope instruments. This in abstract is a good and desirable thing to do, but it will cost money—and exactly the same judgement applies to other NASA missions that are suffering delays, specifically Galileo. So we have to be careful about what we recommend—to be even handed and, as I have said, to consider the ST problem in the context of the entire OSSA program. ST problems should not be allowed to upset the balance in space science activity.

The Board and its Committee on Space Astronomy and Astrophysics are favorably impressed with the organizational arrangements for the Space Telescope Institute. We are pleased to tell you that if the Institute continues on its present track we think that the astronomy community will have a prestigious and effective center in which to carry out its ST research.

As for the rest of the astronomy program, you are aware of the publication during the past year of the report by the Academy's Astronomy Survey Committee. Where the Committee dealt with space. Science issues its recommendations were wholly in consonance with the scientific priorities set by the Board and its committees. I have already discussed the explorer program augmentation. We agree with the recommendation that the next large initiative in space astronomy should be the advanced X-ray astronomical facility, AXAF. In the fiscal year 1984 budget request there seems to be ample accommodation for development and study of future projects. However, as in the case of planetary exploration, but to a lesser degree, there also seems to be the same kind of failure to build on the case that Congress provided in fiscal year 1983 for the research and analysis program.

The Office of Technology Assessment last September published a very useful te'anical memorandum entitled space science research in the Unite(States. We agree with OTA's finding that there is a crisis in spac. science, and this its cause is a lack of stability in the support of research groups that has resulted from the strong mission orientation of NASA's space science program and the present hiatus in mission starts and launches. I am pleased to be able to tell you that NASA at the level of the administrator himself also

recognizes the serious and fundamental nature of this problem. On the initiative of NASA's new chief scientist, Dr. Frank McDonald, a panel consisting of six representatives of the academic community and six representatives of the agency has been formed. It will meet on March 1 and 2 to begin an intensive study, assessing the nature of the problem in NASAUniversity relations and trying to find new ways of doing business that will lead to the desired stability in the Nation's space science program. The Space Science Board will cooperate in this study. It will receive the report of the panel and provide to NASA an assessment of its recommendations. We hope that this effort will address the concerns raised in the OTA memorandum and also provide new and important initiatives to put before you in fiscal 1985.

I would like to express our great satisfaction that NASA has filled the office of chief scientist and that it has selected a person from its own family. Dr. McDonald possesses excellent scientific and personal credentials. Those of us who have interacted with him since his appointment in September have been very impressed with the incisive and insightful way in which he has been helping the administrator and the associate administrator for space science and applications to formulate the science policy that guides NASA science programs.

Finally, let me turn to the space station question. The Board is not yet ready to take a position on whether our next great initiative in space should be the development of a manned space station. We have been asked by Mr. Beggs to identify those characteristics a space station should have and not have in order to meet some of the needs of the space science disciplines. We have agreed to do so, and our committees are still at work on this project. We shall certainly consider the issue of what level of space science activity, if any, would be needed to justify creation of a space station to meet space science needs alone. Since the issue of going ahead with the space station is not raised in the fiscal year 1984 budget request, we prefer to go about reaching our position on this important question at the measured, deliberate tempo that seems to suite an academically oriented body best. We shall be ready to share the results of our assessment with your committee as soon as they are obtained. During any further deliberations, we will be pleased to consider issues that you and your staff believe are important in reaching a decision on whether to proceed with the development of a space station.

Mr. Chairman, this concludes my prepared statement. I shall be happy to respond to your questions now and in writing later after this hearing is concluded.

[The prepared statement of Dr. Donahue follows:]

STATEMENT BY

Thomas M. Donahue
Chairman, Space Science Board
National Academy of Sciences

BEFORE THE

Subcommittee on Space Science and Applications
Committee on Science and Technology
U. S. House of Representatives

FY 84 NASA BUDGET REQUEST

Wednesday, February 23, 1983
Room 2318, Rayburn House Office Building

FY 84 NASA BUDGET REQUEST:

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of support requested for research and analysis for planetary exploration. The amount requested is below the level appropriated by the Congress for 1983. (And here I must take the opportunity warmly to commend the Congress for correcting an alarming cut in funding projected for planetary exploration and for physics and astronomy last year). The amount requested is not sufficient to keep in existence research groups that will be needed to analyze the results NASA hopes to obtain in future planetary missions. I have not carried out the detailed analysis needed to state just how great the shortfall is. As a reasonable guide, I would suggest, as we suggested during this committee's hearings last year, that the level of support in FY 1981, adjusted for inflation, would be adequate to maintain the R&A program in planetary exploration for the near term.

The prospects for the future in the NASA planetary program are certainly enhanced by the promulgation of the long awaited report by the Solar System Exploration Committee (SSEC) of the NASA Advisory Council chaired first by Dr. John Naugle and then by Dr. Noel Hinners. What that Committee has done is to identify a new and affordable way for NASA to conduct missions to the planets that can be carried out by variations on existing Earth orbital spacecraft and by the new JPL series called Mariner Mark II spacecraft. I think that it is important to put the first type of mission on the same stable, relatively low cost basis as the Explorer satellites. Instituting a level

of effort program will allow us to get out of the mode in which every planetary mission becomes an all out effort of the Voyager or Galileo class. The missions identified by SSEC, such as the Mars Geoscience-Climatology Orbiter and the Comet Rendezvous Mission, all conform with the strategy for planetary exploration developed by the Board's Committee on Planetary and Lunar Exploration. Indeed SSEC carefully used COMPLEX reports as a guide and interacted carefully with COMPLEX during its work.

Let me turn now to a less positive development. We are all -- Space Science Board and NASA -- very concerned about the delays that have developed in the Space Telescope (ST) production schedule. The Board has been thoroughly briefed by NASA concerning this problem. We are watching carefully. Our concern is to minimize the damage that may be done to the overall space science program as a result of the additional cost resulting from delay in completion and launch of the Space Telescope. It is important that the Space Telescope, when it is finally flown, be an instrument capable of performing up to the expectations we all have for it. Given the forced relaxation in the telescope delivery schedule there is an opportunity to do more thorough testing and to perfect some of the telescope instruments. This in abstract is a good and desirable thing to do, but it will cost money -- and exactly the same judgement applies to other NASA missions that are suffering delays, specifically Galileo. So we have to be careful about what we

recommend -- to be even handed and, as I have said, to consider the ST problem in the context of the entire OSSA program. ST problems should not be allowed to upset the balance in space science activity.

The Board and its Committee on Space Astronomy and Astrophysics are favorably impressed with the organizational arrangements for the Space Telescope Institute. We are pleased to tell you that if the Institute continues on its present track we think that the Astronomy community will have a prestigious and effective center in which to carry out its ST research.

As for the rest of the Astronomy program, you are aware of the publication during the past year of the report by the Academy's Astronomy Survey Committee. Where that Committee dealt with Space Science issues its recommendations were wholly in consonance with the scientific priorities set by the Board and its Committees. I have already discussed the Explorer program augmentation. We agree with the recommendation that the next large initiative in Space Astronomy should be the Advanced X-Ray Astronomical Facility (AXAF). In the FY 1984 Budget request there seems to be ample accommodation for development and study of future projects. However, as in the case of Planetary Exploration, but to a lesser degree, there seems to be the same kind of failure to build on the base Congress provided in FY 1983 for the Research and Analysis program.

The Office of Technology Assessment last September published a very useful technical memorandum entitled Space Science Research in the United States. We agree with OTA's finding that there is a crisis in Space Science, and that its cause is a lack of stability in the support of research groups that has resulted from the strong mission orientation of NASA's Space Science Program and the present hiatus in mission starts and launches. I am pleased to be able to tell you that NASA at the level of the Administrator himself also recognizes the serious and fundamental nature of this problem. On the initiative of NASA's new Chief Scientist, Dr. Frank McDonald, a panel consisting of six representatives of the academic community and six representatives of the agency has been formed. It will meet on March 1 and 2 to begin an intensive study, assessing the nature of the problem in NASA - University relations and trying to find new ways of doing business that will lead to the desired stability in the nation's Space Science program. The Space Science Board will cooperate in this study. It will receive the report of the panel and provide to NASA an assessment of its recommendations. We hope that this effort will address the concerns raised in the OTA memorandum and also provide new and important initiatives to put before you in FY 1985.

I would like to express our great satisfaction that NASA has filled the position of Chief Scientist and that it has selected a person from its own family. Dr. McDonald possesses

excellent scientific and personal credentials. Those of us who have interacted with him since his appointment in September have been very impressed with the incisive and insightful way in which he has been helping the Administrator and the Associate Administrator for Space Science and Applications to formulate the science policy that guides NASA science programs.

Finally, let me turn to the Space Station question. The Board is not yet ready to take a position on whether our next great initiative in Space should be the development of a manned Space Station. We have been asked by Mr. Beggs to identify those characteristics a space station should have and not have in order to meet some of the needs of the space science disciplines. We have agreed to do so, and our Committees are still at work on this project. We shall certainly consider the issue of what level of space science activity, if any, would be needed to justify creation of a Space Station to meet Space Science needs alone. Since the issue of going ahead with the Space Station is not raised in the FY 1984 budget request, we prefer to go about reaching our position on this important question at the measured, deliberate tempo that seems to suit an academically oriented body best. We shall be ready to share the results of our assessment with your committee as soon as they are obtained. During any further deliberations, we will be pleased to consider issues that you and your staff believe are important in reaching a decision on whether to proceed with the development of a Space Station.

Mr. Chairman, this concludes my prepared statement. I shall be happy to respond to your questions now and in writing later after this hearing is concluded.

Mr. NELSON. Thank you, Dr. Donahue. We'll go ahead and have testimony from each of you. Dr. Hinners if you would like to summarize your statement we'll make the full text a part of the record.

[A biographical sketch of Dr. Hinners follows:]

DR. NOEL W. HINNERS

Dr. Noel W. Hinners is the Director, Goddard Space Flight Center, National Aeronautics and Space Administration (NASA). From April 1979 to June, 1982 he was Director of the National Air and Space Museum. From April 1974 to April 1979 he was the Associate Administrator for Space Science at NASA. While serving in this position, he was responsible for NASA's Lunar and Planetary, Physics and Astronomy, and Life Sciences Programs. Previous to that he was Director of Lunar Programs in the Office of Space Science. In that position, Dr. Hinners was responsible for the continuing scientific exploration of the Moon through analysis and interpretation of lunar data obtained from manned and automated space flights, the acquisition of new data, and the planning for future missions.

Dr. Hinners served as Department Head, Lunar Exploration Department, Bellcomm before going to NASA in 1972. At Bellcomm he conducted studies of the first lunar landing science tasks, lunar soil mechanics, Surveyor lunar roving vehicle, advanced lunar missions, lunar surface science experiments, especially the Apollo Lunar Surface Experiment Packages (ALSEP's), geologic investigations, Apollo orbital science, Apollo 12-17 landing site selection, and overall science mission planning.

Dr. Hinners received his B.Sc. degree in 1958 from Rutgers University in Geology and Soil Chemistry, an M.Sc. in Geochemistry from the California Institute of Technology in 1960 and his Ph.D. from Princeton University in Geochemistry and Geology in 1963.

At Rutgers he graduated with High Honors and was elected a member of Phi Beta Kappa and Sigma Xi. He received National Science Foundation Fellowships in 1960-1963, the NASA Exceptional Scientific Achievement Medal in 1971, and NASA's Distinguished Service Medal in 1977, 1979, and 1981.

Dr. Hinners was the founding Editor (1973-1976) of Geophysical Research Letters, a new journal of the American Geophysical Union devoted to rapid publication of significant research results in earth and space sciences. He is a member of the American Association for the Advancement of Science and the American Geophysical Union (President, Planetology Section).

STATEMENT OF DR. NOEL W. HINNERS, CHAIRMAN, SOLAR SYSTEM EXPLORATION COMMITTEE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. HINNERS. Thank you, Mr. Chairman. I can work either way. If you like, we can work from the figures at the end of the statement. I think some of the points will come through and we can cover it more rapidly than reading the statement.

If you'll turn to [the back what we see here in] figure 1, you'll see a summary in constant 1984 dollars of the history of funding of the planetary exploration program. As you know since the early 1960's the United States has been the world leader in planetary exploration. The activity of the early 1960's was largely reconnaisance-type taking our first look at Mars, Venus, and the Moon. We had a dropoff in the late sixties not unlike that which we saw coming in the late seventies. At that time NASA constituted a review group of scientists from the university community and its own scientists to take a look at where we're headed in planetary exploration.

A redefined science program came up with a new implementation plan which included the likes of the voyager and the viking and the pioneer Venus mission and that accounts for the increase in the early 1970's. The results from that I think you've all seen

and are familiar with. We've learned a tremendous amount about our solar system such as the volcanoes of Jupiter, the rings of Saturn, the intense hot atmosphere of Venus. We're learning to put those pieces together to understand from a global perspective the origin of the solar system. We saw as the late 1970's came that we were headed into a situation in which the number of new missions building on the exploration results from the sixties and early seventies was drastically decreasing; the last new start being Galileo in 1978. Recognizing the trend NASA through the NASA Advisory Council implemented what we call a Solar System Exploration Committee which was charged with taking the science rationale, developed largely by the Space Science Board and developing what we call an implementation strategy. Given the science results from past missions and the science strategy of the Board, how were we to come up with a mission implementation strategy? We were to recognize what the causes of previous problems were and then to build upon that.

We first took a look, shown in figure 2, of those root causes of problems in planetary exploration. Clearly there was a declining planetary science budget caused by a number of things: increasing competition from within the NASA science budget; increasing budgetary competition at the overall NASA level and on a national level. We had requirements for enabling technology. Than meant that before we could implement a mission we required the technology development. For example, we were counting on the development of solar electric propulsion. When it did not come forth we were not able to come forth with a proposed cometary rendezvous mission for Halley's Comet. We were getting into the position of customizing our mission operations which meant that with each new mission we would go build a new operations control center and new softwear to control the mission. These collectively resulted in less frequent mission starts. As the starts decreased the community said let's put everything we can on the one or two opportunities we have. That in turn would drive up the costs again and decrease inheritance from previous missions. We got caught in what we'll call a vicious cycle with the result of abandoning program balance and getting missions trapped in study phase of which the Venus mapper was a prime example. Then that proceeded to impact the research programs.

Clearly we had to come up with an approach of lower cost missions. There was no question about that in our minds. The approach to that is shown in figure 3. The most obvious thing to do is to focus the science objectives. That meant that rather than trying to do everything on each individual mission, we would bite off smaller chunks of science. As an example, on what had previously been a Saturn orbiter and probe mission let's just do the orbiter or just the probe part. We looked for increased resiliency in the use of space craft and launch opportunities. That meant structuring a program to take benefit of the production line, if you will, where you have increased inheritance.

Conventional wisdom in planetary exploration said you had to design a specific spacecraft to go to the planets. We reexamined that and came to the conclusion that it is not always necessary; that for the inner planets the Moon, Venus, Mars, maybe some of

the astroids it is possible with discipline to take an earth orbital (spacecraft) production-type spacecraft and adapt it with minimum modifications to a planetary mission. Another approach is to look at modular design, which JPL calls mariner mark II. Modular design has been proved in concept now in earth orbital spacecraft with the solar maximum mission and the landsat spacecraft. The same generic-type of approach we feel now can be applied to planetary missions. The benefit of that is that when a technology changes or your mission requirement changes you don't have to redesign the entire spacecraft but can adapt and redesign segments of it. You might ask why did we not do that before. Previously our capability was limited with delta, atlas and titan launch vehicles which had very tight weight and volume constraints. A modular approach is inefficient in terms of use of volume and weight. With the advent of the shuttle and the centaur we have the weight capability and volume capability to allow us to efficiently use the modular approach. Optimizing a mission sequence and using instruments on multiple missions is another obvious cost saver. Shared operations, use of automation with the tremendous advances coming now in microcomputers, minicomputers and softwear—artificial intelligence if you will—we find there are many labor saving devices that can be implemented in the planetary exploration program. For example, it now costs us $25 million a year or so to have a launch crew monitor and take care of a spacecraft on its way to Jupiter. We feel that operations costs can be cut down by at least a factor of two, maybe three, by developing automated spacecraft that in essence will be in a hibernation mode during that cruise phase. They will signal us when they need help. In the meantime, our operations crews will be greatly reduced in scope. And that leads to an SSEC recommendation. By utilizing low-cost approaches NASA should implement what we call a balanced core program of high priority science missions of low to moderate cost, aimed at sustained level of about $300 million per year. These missions should not require advanced technology development in and of themselves. We would restrain the science scope of the missions and plan maximum spacecraft inheritance. We realize that an important part of the core program is maintaining or revitalizing the research base. We also recognize the necessity to have a strong mission operations and data analysis underpinning for the core program. Another potential cost saving area which is still in the process of being examined by committies of the Space Science Board and European Science Foundation is increased international cooperation. We expect to be able to report back on that later this year.

The structure in the budgetary sense of the core program is shown in figure 5. What we are looking at is a program aimed at a level of about $300 million per year. You might ask how did we arrive at that particular number. That is close to the historic lows as was shown back in figure 1. It appears to be the budget level at which there is sufficient mission activity in numbers of launches to allow for inheritance continuity of science, continuity of the planet exploration. It is a level which sustains a good basic science program in planetary exploration. It is not the level of program we have seen in the late sixties and early 1970's. And in fact this next

year the committee will be looking at potential augmentations. Those augmentations are not part of what we view as the Core program but are simply a desire to be ready should the budgetary and political situation change in the eighties to respond with some of the more technologically challenging high science priority missions such as comet or Mars sample return.

There are two components of the flight program in the SSEC core program. One you see labeled there planetary observers, and as Dr. Donahue noted, is an analogy to the explorer program where you would have a line item built up for the implementation mainly of the low cost inner planet missions using earth orbiting spacecraft derivatives. Our proposed first mission in the category is the Mars geochemical climatology orbiter which would capitalize upon the results of the previous Mariner and Viking missions to Mars. The Mariner Mars II missions we have aimed at initiation in the 1985–86 time period, targeting the first mission to a comet rendezvous. This would phase nicely now with the foreign missions which are fast flybys of Comet Halley in the 1985–86 time period, and would restore to the U.S. leadership in this very important part of planetary science.

We were pleased to see in fiscal 1984's budget that the administration has proposed that the Venus radar mapper mission be initiated. In the restructuring of that mission from the old VOIR NASA Jet Propulsion Laboratory had implemented many of the cost saving approaches which the committee has studied and recommended this past year, including heavy reliance on the use of spare parts and innovative approaches to mission operations. In structuring the ongoing Core program through the year 2000 we've tried to stick very closely to the program goals which have been in existence shown in figure 6 for over two decades. In evaluating the science of mission candidates we have added a fourth goal for planetary exploration which is to survey resources available in near-Earth space. We have not fooled ourselves into believing that the utilization of near-Earth resources on the Moon or asteroids is something that is going to happen this decade or probably not even early in the next decade. But, we do believe that the potential is there in the distant future for the use of extraterrestrial resources. Before one can make a decision as to whether or not you would like to use the resources you have got to know what's there. So we said we should put in as a science objective a survey of the Moon, Mars, and asteroids to understand enough about their chemistry and geologic makeup to enable one to make decisions later on as to the potential utilization of those resources.

We did prioritize our missions and shown in figure 7 are our top four candidates in the recommended Core program. The Venus radar mapper, the 1984 candidate new start; the Mars mission to initiate the Explorer equivalent which we are calling Planetary Observers; and the Comet Rendezvous mission which would start off the Mariner Mark II series. A Titan probe has taken a high priority in the science mission sequence. The Voyager mission has shown Titan, a moon of Saturn, to be very rich in organic compounds. The scientists' analysis of the Voyager results indicate a high likelihood that Titan is emulating in many ways the primitive

atmosphere of the Earth's early days which has long since disappeared after the origin of life on Earth.

Additional missions complete one cut at looking at a structured program through the year 2000. We realize that it's important to initiate the program with the top four priority missions but that as the program evolves the specific sequence of missions is something which would have to be determined nearer to the time the program would be undertaken. We don't believe that we can foresee now which specific mission, say in 1995, would be the best one with which to proceed. But we do have a firm start for the program, we have tested the strategy that we developed in implementation and have been able to construct a series of sequences of missions which do build upon inheritance, commonality of mission operations, and gain the efficiencies which we sought through the study of the SSEC.

Mr. Chairman, the committee in the 2 years of work now has structured what it believes to be a Core solar system exploration program in response to the budget stringencies of the day. It requires a discipline on the part of all parties involved; that scientists not go out and build larger and larger mission, but be constrained in their objectives; that NASA support a continuity in program planning and implementation; and likewise for the administration and the Congress. We've tried to structure stability and efficiency into the whole planning and implementation process. We all must work together to see that come about. Thank you.

[The prepared statement of Dr. Hinners follows:]

STATEMENT

OF

NOEL W. HINNERS

CHAIRMAN, SOLAR SYSTEM EXPLORATION COMMITTEE

BEFORE THE

COMMITTEE ON SCIENCE AND TECHNOLOGY

SUBCOMMITTEE ON SPACE SCIENCE & APPLICATIONS

U.S. HOUSE OF REPRESENTATIVES

THE SOLAR SYSTEM EXPLORATION COMMITTEE
CONCLUSIONS AND RECOMMENDATIONS

FEBRUARY 23, 1983

19-605 O—83——29

February 23, 1983

The Solar System Exploration Committee
Conclusions and Recommendations

Introduction .

Mr. Chairman and Members of the Subcommittee: I thank you for the opportunity today to report to you on the activities of the Solar System Exploration Committee. As its Chairman for two years, it has been gratifying to see our efforts coalescing into what we intend to be an influential stimulus to our country's planetary exploration program.

Since the early 1960s the United States has been the world leader in solar system exploration. Its automated spacecraft and Apollo lunar missions have provided a wealth of new data which is totally changing our view of the origin, evolution, and physical nature of the solar system. Indeed, two short decades ago, what were only mere shimmers of light as seen through earth-based telescopes have been transformed into new worlds with the likes of hot, carbon dioxide-laden atmospheres (Venus), densely cratered surfaces yielding the early history of the solar system (Moon), dry-ice polar caps and ancient river beds (Mars), sulfur-spewing volcanoes (Jupiter's moon Io), complex rings and organic atmospheres (Saturn and its moon Titan). Even so, we have, as yet, only begun to tap the store of knowledge awaiting us. Comets, asteroids, Uranus, Neptune and Pluto

remain almost totally unexplored and even for those planets for which we have made initial reconnaissance much remains to be done as we attempt to decipher some of nature's grandest mysteries.

The planetary exploration program responsible for these recent discoveries has had its ups and downs over the decades, dramatically shown in the funding chart (Figure 1). As you can see, in the late 1960s planetary exploration appeared to be on a path leading to dissolution but was revived by a joint effort of the scientific community and NASA. That venture led to missions including Viking, Voyager, and Pioneer Venus.

The late 1970s appeared to many of us to hold a repeat of the 1960s problem. The problem, shown schematically in Figure 2, was brought on by a number of forces, some external to the program, such as tighter national and NASA budgets, and some self-induced which included increased individual mission costs brought on by larger, more sophisticated spacecraft and long-trip times to the outer planets. Collectively, these and related factors conspired to exacerbate the problem in that as numbers of new missions decreased further, normal cost-saving techniques depending upon spacecraft and mission inheritance became impossible. As missions decreased in number, desired program balance became unattainable and the research base itself eroded to catastrophic levels.

In response to the predicament NASA, in 1980, formed the Solar System Exploration Committee (SSEC), reporting to the Administrator of NASA through the NASA Advisory Council. The SSEC was charged with devising a new approach to the implementation of solar system exploration, which would recognize the root causes of the problem, build upon the science rationale and strategies of the Space Science Board and NASA working groups, and result in specific, prioritized recommendations to NASA.

The SSEC, comprised primarily of university-based scientists, has spent over two years of analysis and effort aimed at developing recommendations. Its report is in final preparation and a near-final draft was submitted to the NASA Advisory Council just this week. When accepted by NASA the full report will be available to you. Today, I will briefly summarize the SSEC approach and key recommendations.

The SSEC realized that a desirable antidote to the schizophrenic life of the past decade would be to bring stability to the planning and implementation of new missions. If this could be achieved, cost-efficiencies could be realized. We did not fool ourselves about the fiscal situation, however, and targeted towards a recommended Core Program at a budget level only slightly above historic lows. That level, $300 million (shown in Figure 1), was arrived at iteratively as we examined the interplay between lower cost mission approaches and viable rates of scientific investigation. In our considere

opinion, it is a minimum program which is scientifically productive, technically feasible, and economically responsible.

The prime factors we invoked to arrive at lower cost planetary missions are shown in Figure 3. Reducing the scientific scope of individual missions is the most important single factor and one which is possible now because earlier missions have provided data enabling us to address highly focussed scientific questions for many of the planets. We believe that the costs can be further driven down by the increased inheritance possible from utilizing derivatives of earth-orbital spacecraft for inner-planet missions and by creating a modular spacecraft design for outer planets and comet or asteroid missions; by capitalizing upon new technologies of automation; and by planning mission sequences which take advantage of multi-mission operations and instrument use.

The factors above translate into the first SSEC recommendation shown in Figure 4. The actual attributes of the Core Program I°11 address below. An essential adjunct of the Core Program of flight missions is the revitalization and maintenance of a strong research base, a start towards which was made in FY83. Without such a base, we squander prior gains and deplete our scientific and technological resevoir which feeds future exploration with new mission

concepts, instrument developments, and new understandings of our solar system.

We recognize the Core Program as a minimal approach to solar system exploration. It does not accomplish some very high priority science objectives such as, for example, the return of samples from Mars or comets. Such technologically and scientifically challenging, high profile missions must await a more favorable budgetary and political climate in the future.

Although not knowing just when such an opportunity might arise, we believe it prudent to be ready. This coming year the SSEC, under the Chairmanship of Dr. David Morrison of the University of Hawaii,will study how to best put the Program in such a posture.

To further gain exploration economies,the SSEC has recommended that vigorous efforts be made to seek mutually beneficial international cooperation in planetary exploration. Avenues of approach are being explored by committees established under the aegis of the National Academy of Sciences and the European Science Foundation. We anticipate that results of these studies will come into focus later this year.

Now, the content of the Core Program itself. It consists of a solid base of Research and Analysis overlain by

an equally strong Mission Operations and Data Analysis effort which capitalizes upon currently operating and approved flights such as Voyager, Pioneers, and Galileo. These underpinning programs are shown schematically in Figure 5 and constitute 40-50% of the total projected funding. Superposed upon the base are the flight programs, the first of which is the Venus Radar Mapper, a proposed FY84 new start in the NASA budget. The SSEC placed that mission as its number one priority, representative of high quality science to be accomplished in a new mode which incorporates many of the SSEC recommended approaches to lowered mission costs. This mission is now projected at a cost about half of earlier estimates applying to the "old way of doing business."

Subsequent to the Venus mission we recommend establishment of a Planetary Observer program line item building to around $50 million a year, and similar in concept to the Astrophysics Explorer Program. Aimed at highly focussed science objectives and utilizing derivatives of earth-orbiting spacecraft, such an Observer Program would bring a new stability and efficiency to the conduct of the solar system exploration. With total mission costs of around $150 million average, the Planetary Observer Program would be used mainly for the inner planets exploration. The first proposed mission for the Observer is called the Mars Geochemical-Climatological Orbiter, an exciting scientific exploration designed to build upon Viking results and which

would help scientists decipher the global composition and climate of Mars. We recommend that the Observer Program be initiated in FY85 at a low level ($5-10 million) and build up in preparation for a 1990 launch. A small but important component of the Observer Program is that designated "International Missions of Opportunity." Again analogous to the Explorer Program, it would provide funds for individual experiments to be flown on foreign spacecraft. Those opportunities frequently come at times too late for U.S. investigators to respond because of today's minimum two-year budget leadtime.

The remaining important component of the Core Program is the Mariner Mark II missions. More capable than Observers, they are targeted at the $150-$300 million class of mission and utilize the spectrum of new or revitalized approaches to fiscal efficiency with spacecraft modularity, up-to-date technology, highly automated mission operations and inheritance. The first proposed mission is a comet rendezvous in 1990. Cometary exploration is the highest priority mission for the Mariner Mark II, providing critical data on the composition of comets, thought to be residues or even prime unaltered frozen material from the earliest days of the formation of the solar system. The rendezvous mission would capitalize beautifully upon the fast fly-bys of Halley's Comet now underway by other nations. It would restore leadership to the U.S. in this high pay-off scientific arena. As in the Observer Program, effort should

be iniated in FY85 to start the early phase of spacecraft conceptual development.

We have structured the Core Program through the year 2000. Working with the basic Solar System Exploration Goals shown in Figure 6, the SSEC prioritized and selected from a very large "pot" of candidate missions. Note that the SSEC added a fourth basic goal to the three which have been in existance for two decades. It is the "Survey of Resources Available in near-Earth Space." While we believe the actual use of such resources is in the distant future, it is essential to conduct the relevant research in the Core Program in order that one can later make assessments as to the reality of the use of resources in space, especially from the Moon and earth-crossing asteroids.

The high priority Core Program science missions proposed for initiation through the year 2000 are listed in Figure 7. We appreciate that the specific long-term mission sequence after Program initiation is subject to a host of factors and will be iterated in response to conditions existing at the time. Suffice it to say now that we have tested our implementation strategy and find it to be sound - there is no difficulty structuring mission sequences that make sense.

The SSEC Core Program can be structured only because some very basic priority decisions have been made by the

scientific community. It will succeed, however, only if all parties to the process of approval - scientist, NASA, the Administration and Congress - understand its elements and provide the long-term commitment of sticking to the implementation strategy.

Planetary Exploration Funding

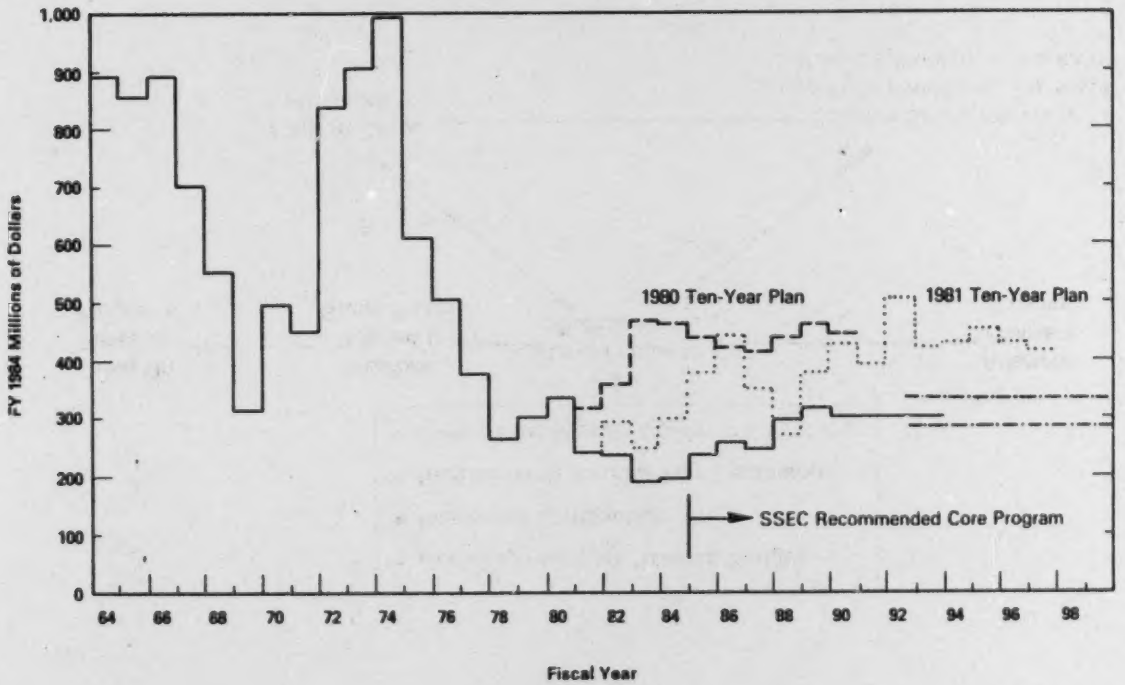

Figure 1

The Problem

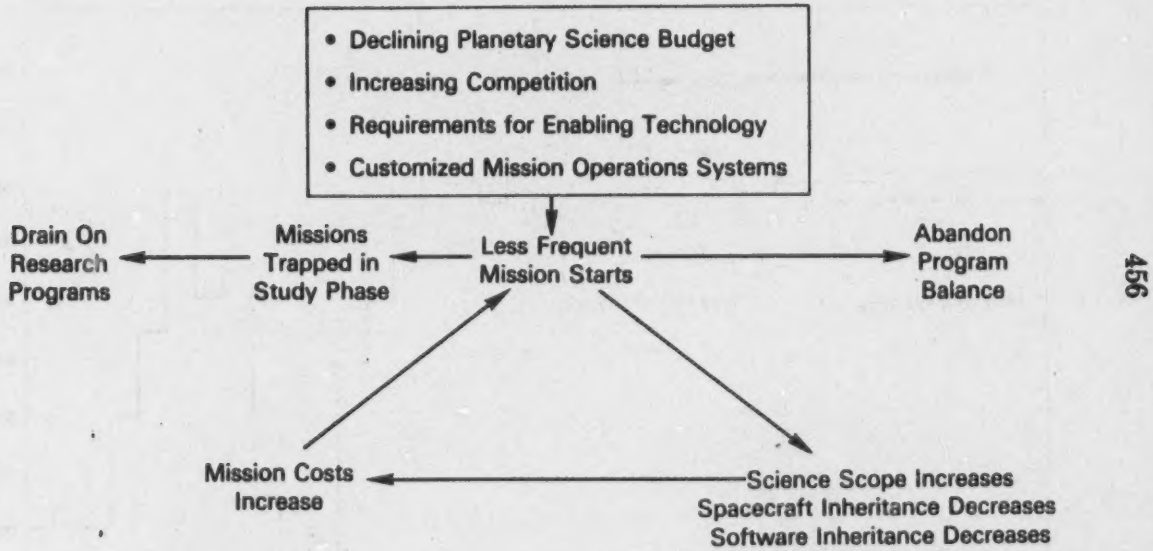

Figure 2.

Approach to Reduce Cost of Planetary Missions

- Focused Science Objectives
- Increased Resiliency
  - Spacecraft
  - Launch Opportunities
- Increased Spacecraft Inheritance
  - Derivatives of Earth Orbital Spacecraft (Planetary Observer)
  - Modular Design (Mariner Mark II)
  - Instrument Multiple Use
  - Optimized Mission Sequence
- Increased Operations Efficiency
  - Shared Operations
  - Automation
  - Optimized Mission Sequence

Figure 3

The SSEC Recommendations

- Implement Balanced Core Program of High Priority Science Missions of Low to Moderate Cost, Aimed at Sustained Level of About $300M per Year (in FY 1984 Dollars)
  - No Requirement for Enabling Technology
    - Omit Mars Sample Return and Mobile Laboratory
  - Restrain Science Scope of Missions
    - Split Missions if Necessary
    - Constrained Imaging
  - Plan Maximum Spacecraft Inheritance
    - Use Spare Hardware
    - Modify Earth Orbiters
    - Design Modular Mariner Mark II
    - Copy Galileo Probe Designs
  - Require Common Mission Operations System
- Maintain Strong Research Base
- Augment Core Program with Technologically Challenging Missions at Earliest Opportunity
- Coordinate Program on International Scale and Undertake Cooperative Programs as Appropriate

Figure 4

Mr. NELSON. Thank you, Dr. Hinners. The committee will suspend for 1 minute. We'll stand in recess for 1 minute.

[Recess taken.]

Mr. NELSON. The committee will come to order. The next witness is Dr. Krimigis.

STATEMENT OF DR. S. M. KRIMIGIS, CHIEF SCIENTIST, SPACE DEPARTMENT, APPLIED PHYSICS LABORATORY, THE JOHNS HOPKINS UNIVERSITY

Dr. KRIMIGIS. Mr. Chairman and members of the subcommittee, I'm testifying on behalf of the Space Science Working Group, a consortium of research universities which participate in NASA-sponsored space science programs.

Let me begin by stating how we at the universities view the objectives of the U.S. Space Science and Exploration activity. The Space Science program addresses scientific questions of the highest intellectual significance; it provides practical information about our own planet Earth; it stimulates the development of new technology; it brings worldwide recognition to the United States for its unchallenged leadership; it attracts young people to careers in science and engineering; it manifests a policy of cooperation with other nations; and is viewed with pride and satisfaction by the U.S. public.

Despite these positive attributes, Federal support of science and exploration has declined to dangerously low levels in the past half dozen years. This decline has damaged space science in the universities, because there are no alternative ways to support the undergraduate students, graduate students, postdoctoral research associates, engineers and technicians who carry out space science projects under the direction of faculty members.

NASA and industry look to the universities for fundamental conceptual advances in spacc instrumentation and research required to make important discoveries. Further, the universities serve as a training ground for future generations of scientists and engineers who contribute the discoveries, innovation and new ideas so essential to our technological leadership and economic well being. These scientists and engineers are employed not only in space-related activities, but mostly in industry and Government where they contribute new concepts to solutions of pressing technological problems. As an example, I recall the case of a recent graduate trained in space instrumentation who is currently working with a small company developing equipment for rapid measurement of sulfur content in coal, an essential tool in our efforts to clean our environment. Such innovations are essential to generating new jobs which are so important to our national economy today.

Last year, the U.S. Congress took positive action to stem the downward trend in space science and exploration. We are very grateful and encouraged by that action which augmented the proposed space science budget and, by doing so, prevented what would have been disastrous consequences for the space science research base in this country. In addition, we wish to commend this committee's attention to, and recognition of the important role of university research in NASA's space science program.

We are also encouraged by the administration's fiscal year 1984 Federal research budget in general, and the NASA budget in particular, which promises the beginning of important progress toward revitalizing space science in the United States. This year, the President's Science Adviser has stressed the importance of Federal support of basic research as a way to strengthen long-term industrial growth and national security. Dr. Keyworth has emphasized both knowledge and training as the important reasons for university-based research and has said that "America's universities are the core of our world leadership in science." We are pleased, Mr. Chairman, to see political leaders of both parties espouse the view that research and development is the keystone to our economic viability, and indeed to our national survival as a modern industrial state.

I would like to comment on some very positive aspects of the NASA space science budget for fiscal year 1984.

First, funding for the Venus radar mapper, the first planetary new start in 5 years signifies NASA's commitment to a planetary program. This mission can be expected to have an important salutary effect on planetary space science in the universities.

Second, there is a significant augmentation of the explorer program which will provide an ongoing level of support of opportunities for small spaceflight experiments of the principal investigator class to be developed in universities and national laboratories.

And third, the funding for the development of the tethered satellite system which will provide a new shuttle capability for conducting experiments in space in future years.

The funding of each of these projects as well as support for other ongoing missions and activities add up to a renewed commitment to a stronger national space science program.

The Space science working group has examined the proposed fiscal year 1984 NASA budget to determine its effect on space science and in particular the research carried out at universities. The budget lines which support university-based activities are research and analysis, (R&A) and mission operations and data analysis (MO&DA). The adequate funding of these budget line items are critical to the conduct of basic research and scientific training and are relatively inexpensive to sustain in the context of the overall NASA budget.

To fulfill our commitment in strengthening research at the universities; that is, fostering innovation, high technology, training of new talent, et cetera, we have identified some areas in the budget where a small augmentation is likely to result in significant scientific and technological advancements. We consider these augmentations to be critical to the vitality of space science at the universities.

The requested augmentations for planetary exploration research and analysis is $11 million; for physics and astronomy research and analysis $4 million; and for space physics advanced technology development $2 million for a total of $17 million.

This $17 million augmentation is for the various research and analysis (R&A), lines which directly support experimental and theoretical research at universities as well as conceptual and experimental developments that form the basis for new missions.

Let me now explain in more detail the reasons for these requests. In planetary research and analysis the recommended augmentation of $11 million is for basic planetary research programs. This basic research is an important component of the NASA space science program and, in part, represents the means by which results of spacecraft investigations are turned into real knowledge and understanding. The administration's request for $4.8 million below the congressional appropriation for fiscal year 1983 is clearly inadequate. The recommended augmentation will forestall large additional reductions in the Nation's basic planetary research programs in universities and national laboratories, and will allow very modest steps toward restoring these programs to a minimally acceptable level of vigor. It will also permit a very modest start of an outer planets data analysis program. While the regular mission operations and data analysis MO&DA funds allow for the basic reduction of raw data to a usable form and for preliminary interpretation by the spacecraft teams. This data analysis program will permit general access to and use of the date by the wider scientific community. Data analysis programs of this type provide the means of exploiting and developing information gained through spacecraft investigations, and an important way to bring new young scientists into the scientific program.

In physics and astronomy research and analysis the recommended augmentation is $4 million. This augmentation is recommended for basic research programs. A major portion of R&A funding directly supports experimental and theoretical research at universities which interpret and disseminate the scientific results from flight programs. Another major portion supports the conceptual and experimental developments that form the basis for new missions. The congressional action of adding $2 million to the President's fiscal year 1983 budget for this line item has provided much needed support for rejuvenation of this vital area of NASA's basic research base. The recommended augmentation for fiscal year 1984 would restore support to approximately the fiscal year 1981 level, which was already seriously constrained.

In the area of environmental observations advanced technology development research and analysis we recommend an augmentation of $2 million.

This augmentation is specifically recommended for the program called origin of plasmas in the Earth's neighborhood, OPEN. Although this line item has shown some nominal growth from fiscal year 1983 to fiscal year 1984, funding for the only effort in advanced technology development, the OPEN program, has decreased from $3.5 million in fiscal year 1983 to a proposed $1.8 million in fiscal year 1984. The OPEN program represents the only major U.S. initative in space plasma physics in this decade, with extensive involvement by university investigators in over 30 experiments. The proposed funding level of $1.8 million is insufficient to support these university teams in pursuit of further experiment definition activities. We therefore deem it essential that these university teams continue to be supported.

In our opinion the $17 million augmentation to the fiscal year 1984 budget is crucial for space science at universities. However, there are additional problems confronting these areas of research

to which we also call attention. The ultimate viability of university research programs in the space sciences requires that these problems also be addressed.

Planetary research and analysis additional $8 million. Restoring the planetary program to its already constricted fiscal year 1981 level of effort would require an augmentation to the proposed fiscal year 1984 budget of $19 million. The $11 million labeled as crucial above goes part way, but the remaining $8 million must ultimately be restored. We concur with the analysis of the division of planetary sciences of the American Astronomical Society regarding these increments and endorse their recommendations.

Shuttle/spacelab payload development, in physics and astronomy and environmental observations—an additional $6 million. In response to an announcement of opportunity issued by NASA in 1978, about 300 proposals were received and 29 U.S. principal investigator, PI-class experiments were selected. Of these 29, only 3 have been funded for development and 13 more for definition studies, leaving 13 selected but not funded. With the successful completion of the shuttle orbital test flight program, we urge that the potential afforded by shuttle for useful science be realized by a more vigorous program of PI-class experiments. We urge NASA to study the spacelab program and modify the ground rules for experiment implementation so the development of substantially more PI-class instruments can be carried out without significant increase in the budget. Effective university participation depends on reducing costs and simplifying procedures for PI experiments on spacelab. At the same time, additional funding of $6 million would permit further activity in definition and development of these selected investigations.

Suborbital programs additional $2 million. An addition of $2 million to the sounding rocket program for Spartan development would permit significant advancement in one realistic approach to the process of shuttle experiment flight. The Spartan program takes payloads developed under the suborbital sounding rocket program, and uses shuttle to place them in orbit and retrieve them 2 or 3 days later. As part of the fiscal year 1983 budget action in Congress last year, $1 million was added to the suborbital program and this addition is being applied to the sounding rocket program for Spartan. The fiscal year 1984 sounding rocket line in the President's budget seems to be based upon the fiscal year 1983 budget before this $1 million was added.

Laboratory equipment, recommended addition of $6 million to R&A. We propose beginning a new program of upgrading laboratory capital equipment at universities. A decade of underfunding has resulted in a general obsolescence of the research equipment used in universities for basic studies aimed at development of concepts and instruments for future space science missions, and at analysis and interpretation of data from previous missions. The problem of NASA-funded research groups is part of a general problem in universities which has been addressed in recent statements by Dr. Keyworth. We consider it essential that NASA develop a new program of grants for acquisition of research equipment at universities and recommend an increment of $6 million specifically toward this end, with $3 in the physics and astronomy R&A, $2

million in planetary exploration R&A, and $1 million in space physics R&A.

All of the items enumerated so far add up to about one-half of 1 percent of the total NASA budget. Yet this relatively small amount provides high leverage in terms of technological innovation and scientific advancement. These funds would go a long way toward restoring a degree of relative health in space science activities at the Nation's research universities. Our detailed analysis of the space science budget and its development from fiscal year 1981 is given in appendix A for your information and perusal.

I would like to comment briefly on two other areas of the subcommittee's concern:

One is the OTA technical memorandum on space science. We are in general agreement with the general thrust of this memorandum, as far as it goes. The report emphasized the difficulties of planetary science, which appeared to be the most pressing issue at the time. However, the predicament of other branches of space science, including solar and magnetospheric physics and X-ray astronomy, among others, is equally severe. The end result is that the United States is slowly dropping out of several fields of space science because of the interminable studies, delays, and eventual cancellation of several well planned programs in the late seventies and early eighties. As a consequence, leadership in space sciences may well pass to other countries with a more determined approach, such as Germany, France, Japan and the U.S.S.R. A more detailed discussion of these issues, prepared by Prof. E. N. Parker of the University of Chicago and reflecting the thinking of the space science working group, is appended to this statement as appendix B.

Second, I would like to make a comment on behalf of the space science working group that we are most favorable to the continued development of the space telescope and its proposed operation through the Space Telescope Science Institute. It is a good example of NASA's development of a facility whereby access is provided to the university community through competitive selection of focal point instrumentation and of guest observers.

Finally, Mr. Chairman and members of the subcommittee, let me say that, on behalf of the space science working group, I am most appreciative of the opportunity to present the concerns of the Nation's leading research universities to this subcommittee. Thank you.

[The prepared statement of Dr. Krimigis follows:]

TESTIMONY

on

FY-1984 NASA AUTHORIZATION ACT

for the

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

presented before the

SUBCOMMITTEE ON

SPACE SCIENCE AND APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

by

DR. S. M. KRIMIGIS, CHIEF SCIENTIST

SPACE DEPARTMENT

APPLIED PHYSICS LABORATORY

THE JOHNS HOPKINS UNIVERSITY

on behalf of the

SPACE SCIENCE WORKING GROUP

ASSOCIATION OF AMERICAN UNIVERSITIES

FEBRUARY 23, 1983

BIOGRAPHY

Dr. S. M. (Tom) Krimigis was educated at the Universities of Minnesota (B. Phys., 1961) and Iowa (M.S., 1963; PhD, 1965, both in Physics). He joined the Applied Physics Laboratory/The Johns Hopkins University in 1968, where he serves currently as Chief Scientist in the Space Department. He has been Principal Investigator on several NASA spacecraft, most recently on Voyagers-1 and 2 to Jupiter, Saturn and beyond. He has served on several National Academy and NASA Committees and is a member of the Steering Committee of the Space Science Working Group.

Mr. Chairman Volkmer and Members of the Subcommittee, I am Dr. S. M. Krimigis, of the Applied Physics Laboratory, The Johns Hopkins University where I serve as Chief Scientist in the Space Department, and I am testifying before this subcommittee on behalf of the Space Science Working Group, a consortium of research universities which participate in NASA-sponsored space science programs.

Let me begin by stating how we at the universities view the objectives of the U.S. Space Science and Exploration activity. The Space Science program

- addresses scientific questions of the highest intellectual significance;
- provides practical information about our own planet Earth;
- stimulates the development of new technology;
- brings worldwide recognition to the U.S. for its unchallenged leadership;
- attracts young people to careers in science and engineering;
- manifests a policy of cooperation with other nations; and
- is viewed with pride and satisfaction by the U.S. public.

SSEC Core Program Overview

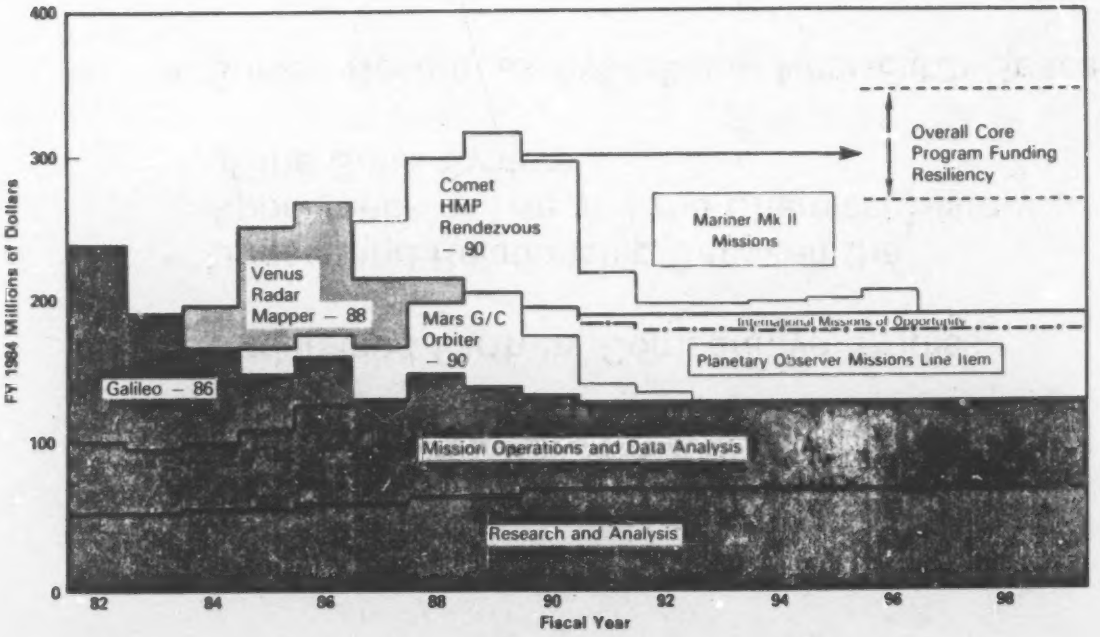

Figure 5

Solar System Exploration Program Goals

- Determine Present State, Origin, and Evolution of the Solar System
- Understand Earth by Comparative Studies
- Understand Relationship Between the Appearance of Life and the Chemical History of the Solar System
- Survey Resources Available in Near-Earth Space

Figure 6

19-006 O—83—30

Recommended Core Program

- Venus Radar Mapper
- Mars Geoscience/Climatology Orbiter
- Comet Rendezvous
- Titan Probe

- Mars Aeronomy Orbiter
- Mars Probe Network
- Venus Atmospheric Probe
- Lunar Orbiter

- Saturn Probe
- Saturn Orbiter
- Uranus Probe

- Comet Atomized Sample Return
- Multi Main-belt Asteroid Orbiter and Flyby
- Earth Approaching Asteroid Rendezvous

Figure 7

Despite these positive attributes, federal support of space science and exploration has declined to dangerously low levels in the past half dozen years. This decline has damaged space science in the universities, because there are no alternative ways to support the undergraduate students, graduate students, postdoctoral research associates, engineers and technicians who carry out space science projects under the direction of faculty members.

NASA and industry look to the universities for fundamental conceptual advances in space instrumentation and research required to make spectactular discoveries. Further, the universities serve as the training ground for future generations of scientists and engineers who contribute the discoveries, innovation and new ideas so essential to our technological leadership and economic well being. These scientists and engineers are employed not only in space-related activities, but mostly in industry and government where they contribute new concepts to solution of pressing technological problems. As an example, I recall the case of a recent graduate trained in space instrumentation who is currently working with a small company developing equipment for rapid measurement of sulfur content in coal, an essential tool in our efforts to clean our environment. Such innovations are essential to generating new jobs which are so important to our national economy today.

Last year, the U.S. Congress took positive action to stem the downward trend in space science and exploration. We are very grateful and encouraged by that action which augmented the proposed space science budget and, by doing so, prevented what would have been disastrous consequences for the space science research base in this country. In addition, we wish to

commend this Committee's attention to, and recognition of the important role of university research in NASA's space science program.

We are also encouraged by the Administration's FY-1984 federal research budget in general, and the NASA budget in particular, which promises the beginning of important progress toward revitalizing space science in the United States. This year, the President's Science Advisor has stressed the importance of federal support of basic research as a way to strengthen long-term industrial growth and national security. Dr. Keyworth has emphasized both knowledge and training as the important reasons for university-based research and has said that "America's universities are the core of our world leadership in science." We are pleased Mr. Chairman, to see political leaders of both parties espouse the view that research and development is the keystone to our economic viability, and indeed to our national survival as a modern industrial state.

I would like to comment on some very positive aspects of the NASA and space science budget for FY-1984.

- Funding for the Venus Radar Mapper, the first planetary new start in five years signifies NASA's commitment to a planetary program. This mission can be expected to have an important salutary effect on planetary space science in the universities.

- There is a significant augmentation of the Explorer program which will provide an ongoing level of

support of opportunities for small spaceflight experiments of the Principal Investigator class to be developed in universities and national laboratories.

- Funding for the development of the Tethered Satellite system will provide a new Shuttle capability for conducting experiments in space in future years.

The funding of each of these projects as well as support for other ongoing missions and activities add up to a renewed commitment to a stronger national space program.

Recommendations of the Space Science Working Group

The Space Science Working Group has examined the proposed FY-1984 NASA budget to determine its effect on space science, in particular the research carried out at universities. The budget lines which support university-based activities are Research and Analysis (R&A) and Mission Operations and Data Analysis (MO&DA). The adequate funding of these budget line items are critical to the conduct of basic research and scientific training and are relatively inexpensive to sustain in the context of the overall NASA budget.

To fulfill our commitment in strengthening research at the universities, i.e. fostering innovation, high technology, training of new talent, etc. we have identified some areas in the budget where a small augmentation is likely to result in significant scientific and technological advancements. We consider these augmentations to be critical to the vitality of space science at universities.

Planetary Exploration Research and Analysis	$11 million (M)
Physics and Astronomy Research and Analysis	$4M
Environmental Observations - Space Physics ATD Research and Analysis	$2M
TOTAL	$17M

This $17M augmentation is for the various Research and Analysis (R&A) lines which directly support experimental and theoretical research at universities as well as conceptual and experimental developments that form the basis of new missions.

Planetary Research and Analysis — Recommended Augmentation $11M

This augmentation is for the basic planetary research programs. This basic research is an important component of the NASA space science program and, in part, represents the means by which results of spacecraft investigations are turned into real knowledge and understanding. The administration's request is $4.8 million below the Congressional appropriation for FY-1983. The recommended augmentation will forestall large additional reductions in the nation's basic planetary research programs in universities and national laboratories, and will allow very modest steps toward restoring these programs to a minimally acceptable level of vigor. It will also permit a very modest start of an Outer Planets Data Analysis program. The regular mission operations funds allow for the basic reduction of raw data to a usable form and for preliminary interpretation by the spacecraft teams. This Data Analysis program will permit general access to and use of the data by the wider scientific community. Data analysis programs of this type provide the means of exploiting and developing information gained through spacecraft investigations, and an important way to bring new young scientists into the scientific program.

Physics and Astronomy Research and Analysis — Recommended Augmentation $4M

This augmentation is recommended for basic research programs. A major portion of R&A funding directly supports experimental and theoretical research at universities which interpret and disseminate the scientific results from flight programs. Another major portion supports the conceptual and experimental developments that form the basis for new missions. The congressional action of adding $2M to the President's FY-83 budget for this line item has provided much needed support for rejuvenation of this vital area of NASA's basic research base. The recommended augmentation would restore support to approximately the FY-81 level, which was already seriously constrained.

Environmental Observations Space Physics/ATD Research and Analysis

Recommended Augmentation $2M

This augmentation is recommended for the Advanced Technology Development (ATD) for the program Origin of Plasmas in the Earth's Neighborhood (OPEN). Although this line item has shown some nominal (3%) growth from FY-83 to FY-84, funding for the only effort in Advanced Technology Development, the OPEN program, has decreased from $3.5M in FY-83 to a proposed $1.8M in FY-84. The OPEN program represents the only major U.S. initiative in space plasma physics in this decade, with extensive involvement by University investigators in over 30 experiments. The proposed funding level of $1.8M is insufficiant to support these University teams in pursuit of further experiment definition activities. We deem it essential that these university teams continue to be supported.

Additional Problem Areas

In our opinion the $17M augmentation to the FY-1984 budget is crucial for space science at universities; however, there are additional problems confronting these areas of research to which we also call attention. The ultimate viability of university research programs in the space sciences requires that these problems also be addressed:

Planetary Research and Analysis - Additional $8M - Restoring the planetary program to its already constricted FY-1981 level of effort would require an augmentation to the proposd FY-1984 budget of $19M. the $11M labelled as crucial above goes part way, but the remaining $8M must ultimately be restored. We concur with the analysis of the Division of Planetary Sciences of the American Astronomical Society regarding these increments and endorse their recommendations.

Shuttle/Spacelab Payload Development (Physics and Astronomy, and Space Plasma Physics of Environmental Observations) - Additional $6M - In response to an Announcement of Opportunity issued by NASA in 1978, about 300 proposals were received and 29 U.S. funded Principal Investigator (PI) class experiments were selected. Of these 29, only three have been funded for development and thirteen more for definition studies, leaving thirteen selected but not funded. With the successful completion of the Shuttle orbital test flight program, we urge that the potential afforded by Shuttle for useful science be realized by a more vigorous program of PI-class experiments. We urge NASA to study the Spacelab program and modify the ground rules for experiment implementation so that development of substantially more PI-

class instruments can be carried out without significant increase in the budget. Effective university participation depends on reducing costs and simplifying procedures for PI experiments on Spacelab. At the same time additional funding of $6M would permit further activity in definition and development of these selected investigations.

Suborbital Programs - Additional $2M - An addition of $2M to the sounding rocket program for SPARTAN development would permit significant advance in one realistic approach to the process of Shuttle experiment flight. The SPARTAN program takes payloads developed under the suborbital sounding rocket program, and uses Shuttle to place them in orbit and retrieve them two or three days later. As part of the FY-83 budget action in Congress last year, $1M was added to the suborbital program and this addition is being applied to the sounding rocket program for SPARTAN. The FY-84 sounding rocket line in the President's budget seems to be based upon the FY-83 budget before this $1M was added.

Laboratory Equipment - Recommended Addition of $6M to R&A - We propose beginning a new program of upgrading laboratory capital equipment at universities. A decade of underfunding has resulted in a general obsolescence of the research equipment used in universities for basic studies aimed at development of concepts and instruments for future space science missions, and at analysis and interpreation of data from previous missions. This problem of NASA-funded research groups is part of a general problem in universities which has been addressed in recent statements by Dr. Keyworth. We consider it essential that NASA develop a new program of grants for acquisition of research equipment at universities and recommend an increment of $6M

specifically toward this end, with $3M in the Physics and Astronomy R&A, $2M in Planetary Exploration R&A, and $1M in Space Physics R&A.

All of the items enumerated so far add up to a total of $39 million, which is only about 0.5 percent of the total NASA budget. Yet this relatively small amount provides high leverage in terms of technological innovation and scientific advancement. These funds would go a long way towards restoring a degree of relative health in space science activities at the nation's research universities.

Our detailed analysis of the space science budget and its development from FY-81 is given in Appendix A for your information and perusal.

I would also like to comment briefly on two other areas of the Subcommittee's concern:

(1) The OTA Technical Memorandum on space science. We are in general agreement with the general thrust of this memorandum, as far as it goes. The report emphasized the difficulties of planetary science, which appeared to be the most pressing issue at the time. However, the predicament of other branches of space science, including solar and magnetospheric physics and x-ray astronomy, is equally severe. The end result is that the U.S. is slowly dropping out of several fields of space science because of the interminable studies, delays, and eventual cancellation of several well-planned programs in the late seventies and early eighties. As a consequence, leadership in space sciences may well pass to other countries with a more determined approach, such as Germny, France, Japan and the U.S.S.R. A more

detailed discussion of these issues, prepared by Professor E. N. Parker at the University of Chicago and reflecting the thinking of the SSWG, is appended to this statement as Appendix B.

(2) The SSWG is most favorable to the continued development of the Space Telescope and its proposed operation through the ST Science Institute. It is a good example of NASA's development of a facility whereby access is provided to the university community through competitive selection of focal point instrumentation and of guest observers.

Finally, Mr. Chairman and Members of the Subcommittee, let me say that, on behalf of the Space Science Working Group, I am most appreciative of the opportunity to present the concerns of the nation's leading research universities to this Subcommittee.

APPENDICES

Appendix A Space Science at Universities in the FY-84 NASA Budget

Appendix B Comments on the U.S. Space Science Situation
(by Professor E. N. Parker)

APPENDIX A

SPACE SCIENCE AT UNIVERSITIES IN THE FY 1984 NASA BUDGET

Introduction

This report summarizes the effect on space science of the President's proposed FY 1984 NASA budget. (See Table 1 attached) It emphasizes aspects of the budget of the Office of Space Science and Applications (OSSA) which fund research at universities.

The proposed budget includes two valuable new items, a new start for the Venus Radar Mapper and a significant augmentation in the Explorer budget. Both of these spaceflight programs are of great value to space science, and of special interest to university scientists.

At the same time the FY 1984 budget continues a serious erosion of the science base support for research and analysis, particularly in the Planetary Exploration program, although the rate of erosion is not as drastic as was proposed a year ago in the President's FY 1983 budget.

Background

The lines of NASA's budget which provide the most research funding to universities are Research and Analysis (R&A) and Mission Operations and Data Analysis (MO&DA). There is an R&A line in each of the OSSA programs and an MO&DA or an Extended Mission Operation line in most of the programs. Funds for R&A support basic research programs from which many relatively inexpensive science results emerge and from which come the new concepts that are the foundation for future major spaceflight missions. The MO&DA line principally supports operation of spacecraft which are in orbit and analysis of data from operating and recently terminated spacecraft.

A year ago, the FY 1982 operating plan and the President's proposed FY 1983 budget contained drastic cuts compared to FY 1981 in the Planetary program for both R&A and MO&DA, as well as significant but less drastic cuts in real support levels (after accounting for inflation) in Physics and Astronomy. Analysis by the Space Science Working Group showed that an additional $60 million ($40 M in Planetary Exploration and $20 M in Physics and Astronomy) was needed in the FY 1983 budget to preserve the (already tight) FY 1981 level of research effort. Action on the FY 1983 budget by the Congress, adding $27 M to the Planetary budget and $5 M to Physics and Astronomy, significantly reduced the damaging effects of the proposed budget. The result has been that, while FY 1983 sees a continued belt-tightening in which inflation is eroding the level of university research, the Planetary program has been saved from dismantling.

While the proposed FY 1984 budget does not contain cuts as drastic as those which were proposed for FY 1983, it still imposes a substantial decrease in support for R&A below FY 1981 levels. The problem is especially evident in the Planetary R&A line, for which the proposed FY 1984 level is 10% below the FY 1983 operating plan, which in turn is not quite at the FY 1981 level. Following is a line-by-line summary of the space science budget.

PHYSICS AND ASTRONOMY

Space Telescope Development -- The reduction from FY 1983 to FY 1984 is as expected since the peak development costs are past. ST continues toward a 1985 launch, and promises to be an extremely valuable astronomical observatory.

Gamma Ray Observatory Development -- The increase from FY 1983 to FY 1984 is as expected as peak development costs (in 1985) approach. This important advance in high-energy astrophysics is proceeding toward a 1988 launch.

Shuttle/Spacelab Payload Development -- The FY 1984 budget level is a 12% increase over FY 1983. This level permits continued development of the Solar Optical Telescope (SOT), as well as definition of the Shuttle Infrared Telescope Facilities (SIRTF) two major facilities designed for repeated flights; these are of great value to solar physics and to infra-red astronomy respectively. Also under this budget line are data analysis of Spacelab-1, scheduled for launch in 1983, and continued development of the Spacelab-2 experiments scheduled for launch in 1985 and of three ultraviolet instruments (designated OSS-3) scheduled for launch in 1986 to observe Comet Halley. The line includes $2 M for studies to define potential payloads for a space station. The proposed FY 1984 funding level will permit the start of development of three x-ray astronomy instruments (designated OSS-2) which had been selected but not funded for development in 1979 as a result of the Announcement of Opportunity for Spacelab payloads.

There is a major backlog of other "selected but not funded" investigations for Spacelab which will remain unfunded in FY 1984. Of 29 U.S. experiments of the principal investigator (PI) type (as contrasted to facilities) which were selected in 1979, by December 1982 only three (OSS-3) have been funded for development, thirteen have received some definition study funding, and another thirteen have received no funding.

Explorer Development -- The FY 1984 budget requests a significant augmentation of the funding level for this line, from $34.3 M in FY 1983 to $48.7 M in FY 1984. The Explorer program is of great value to space science. Its most recent success was the launch, in January of this year, of the Infrared Astronomy Satellite (IRAS). The Explorer program is of special importance to universities because it provides an ongoing level of support for

relatively small, usually PI class spaceflight investigations. This line has been fixed near $30 M for many years, with the result that inflation has forced a long stretch-out of the Explorer program. The proposed FY 1984 augmentation makes a significant step toward restoring the productivity of this program and is responsive to one of the recommendations of the National Academy of Sciences Astronomy Survey Committee. It will permit an FY 1984 start on development of the Extreme Ultraviolet Explorer (EUVE), a university-based, principal investigator experiment. The EUVE was selected for flight as a result of a competitive Announcement of Opportunity seven years ago and has been on hold ever since. We note with approval that the queue of previously selected Explorers has been reduced sufficiently to permit the recent selection of the X-Ray Timing Explorer (XTE) for future development. Definition studies for XTE are funded in this 1984 budget, and a development start is likely in late 1985. The budget also permits continued development of the Active Magnetospheric Particle Tracer Explorer (AMPTE), the Cosmic Background Explorer (COBE), and U.S. instrumentation which fly on the German Roentgen Satellite (ROSAT).

Mission Operations and Data Analysis -- This line in the Physics and Astronomy budget appears to be funded at an adequate level in FY 1984 to support operations and analysis of the IRAS, AMPTE, and International Ultraviolet Explorer (IUE), and extended analysis of data from the High Energy Astronomy Observatories (HEAO). The budget also supports the in-orbit repair and continued operation of the Solar Maximum Mission (SMM), and preparation for Space Telescope operations and refurbishment. The SMM repair mission will provide a valuable extension of this significant solar investigation, as well as the first demonstration of the in-orbit repair capability of the Shuttle.

Research and Analysis -- This critical line of the budget shows a $1 M (3.5%) increase from FY 1983 to FY 1984. Apparently the FY 1984 proposal carries an inflationary increase of about 10% over the proposed FY 1983 budget, ignoring the $2 M which was added to this line as a result of the FY 1983 Congressional action. While this looks like a healthy increase over FY 1982, it must be remembered that the FY 1982 budget was 13% below that of FY 1981 in this line. In fact, the proposed FY 1984 budget is only about 13% above the FY 1981 budget, certainly not an inflationary growth; and this budget had fallen 15% between FY 1979 and FY 1981. The Physics and Astronomy R&A includes three subdivisions: Supporting Research and Technology (SR&T) which funds basic experimental and theoretical research, principally at universities; this part is down $0.5 M from FY 1983. Advanced Technology Development (ATD), is up $1.2 M from FY 1983; this part will principally be used for studies of the Advanced X-Ray Astrophysics Facility (AXAF), a 1.2 m X-ray telescope which was the highest priority in the recent National Academy of Science Astronomy Survey Committee report. Data Analysis of past missions is up $0.3 M from FY 1983.

(Note, it is difficult to compare the FY 1984 budget document, which includes figures for FY 1982 and 1983, with earlier documents giving FY 1981 figures because Space Plasma Physics R&A was included in the Physics and Astronomy R&A line in Fy 1981 but now appears in Environmental Observations R&A where it is combined with some items that appeared in the suborbital part of Physics & Astronomy in FY 1981. See Table 2.)

Suborbital Programs -- This budget line supports aircraft, balloon, and sounding rocket programs which combine with R&A efforts to yield important scientific results at relatively low cost with relatively quick turn-around. These programs are ideally suited for university based research programs, particularly those involved in the training of graduate students. About half of the $5 M (11%) increase from FY 1983 to FY 1984 will pay for basic support of the National Scientitic Balloon Facility (NSBF) which has been transferred from he National Science Foundatior to NASA. While this transfer took effect at the beginning of FY 1983, the full cost was not included in this line of the FY 1983 budget. Aside from the increase for the NSBF, it appears that the FY 1984 budget proposal represents an increase of about 7% over the proposed FY 1983 budget, and ignores the $1 M which was added to the sounding rocket program as a result of the Congressional action.

(As with the R&A line, direct comparison of the current budget proposal with FY 1981 levels is difficult because of transfer of the Applications Airborne program into this line. See Table 3.)

PLANETARY EXPLORATION

Galileo Development -- The proposed FY 1984 budget includes funding for continuation of the Galileo program, progressing toward a launch in 1986. This program is well past its peak development costs, so this budget line is $19 M lower in FY 1984 than in FY 1983.

Venus Radar Mapper (VRM) -- The President's budget proposes $29 M for an FY 1984 new start of this mission. This is the first planetary new start since that of Galileo in FY 1978. VRM, which has the endorsement of the Space Science Board is a less ambitious exploration of Venus than the Venus Orbiting Imaging Radar (VOIR) mission which had been proposed by NASA a year ago for a new start, but was not included in the President's budget. VRM preserves the principle objective of VOIR, radar mapping of the entire planet, but does so with somewhat lower resolution and without several ancillary observations that had been part of VOIR. The projected runout costs of VRM through FY 1988, the proposed year of launch, are approximately $340 M, compared with roughly twice that for VOIR. VRM is an extremely valuable step in planetary exploration which will have the active participation of a number of university scientists.

International Solar Polar Mission (ISPM) -- The FY 1984 budget continues to fund the US experimenters on the European ISPM spacecraft which is also scheduled for 1986 launch.

Mission Operations and Data Analysis -- The proposed level of $43.4 M, up 13% from the FY 1983 operating plan, appears to be adequate for operation of the Pioneer and Voyager spacecraft, which had been threatened with termination by the President's FY 19[illegible] proposal and were saved by Congressional action. It also includes funds for development of systems needed for operation of Galileo and ISPM.

Research and Analysis -- Here we have a continued serious erosion of the science base upon which the planetary program rests. The proposed FY 1984 level of $45.5 M is 10% lower than the FY 1981 level of $50.7 M. While this is not as damaging as the 30% cut which had been proposed a year ago for FY 1983, it is still a drastic reduction when three years' inflation is considered. While the FY 1984 proposed level is $10 M higher than the President's FY 1983 proposal, it is nearly $5 M lower than the actual FY 1983 operating plan which resulted from Congressional action on the FY 1983 budget. This 10% cut is distributed almost uniformly over all the planetary R&A components except for the Halley's Comet program which remains at $2.2 M in FY 1984, the same as FY 1983.

ENVIRONMENTAL OBSERVATIONS

Research and Analysis -- R&A in Environmental Observations includes programs in upper atmosphere, atmospheric dynamics, oceans, and space plasma physics. The space plasma physics part was previously included in the Physics & Astronomy R&A, (see Table 2) and this part is seen as space science while the other aspects of the Environmental Observations program are more directed toward space applications. FY 1984 shows modest growth in these lines from FY 1983. One item of concern to the space plasma physics community is the relatively low priority in Environmental Observations on definition of the mission Origin of Plasmas in the Earth's Neighborhood (OPEN) for which experimenters were selected two years ago. This mission had enjoyed higher priority when space plasmas were part of Physics and Astronomy. The Advanced Technology Development (ATD) portion of this R&A line which includes funding for OPEN definition drops from $3.5 M in FY 1983 to $1.8 M in FY 1984, resulting in serious cuts for the definition efforts of experimenters who have been selected for this mission.

Upper Atmosphere Research Satellite (UARS) -- Development of experiments for this mission continues but the FY 1984 budget does not permit a start of the spacecraft development. It is hoped that this new start will occur in early 1985. UARS will provide the first global measurements of stratospheric & mesopheric ozone, chemical species that affect ozone, energy inputs, temperatures and winds.

TABLE 1

SPACE SCIENCE IN THE NASA OSSA BUDGET
(in millions of dollars)

	1981	1982	1983	1984
Total NASA	5425.6	6020.0	6839.4	7106.5
Total Research & Development	4334.3	4772.0	5542.8	5708.5
Total Space Science & Applications	873.0	896.2	1034.1	1068.0
Total Physics & Astronomy	323.7	322.4	441.0	514.6
Space Telescope Development	119.3	121.5	137.5	120.6
Gamma Ray Observatory	8.2	8.0	34.5	89.8
Shuttle/Spacelab	27.4	47.6	83.0	92.9
Explorer Development	33.3	33.3	34.3	48.7
Mission Operations & Data Analysis	38.9	45.3	74.8	79.5
Research & Analysis	37.7*	22.9	28.8	29.8
Suborbital	30.9*	43.8	48.1	53.3
Total Planetary Exploration	175.6	210.0	186.4	205.4
Galileo	63.1	115.7	91.6	79.5
Venus Radar Mapper	-	-	-	29.0
International Solar Polar	28.0**	5.0	6.0	8.0
Mission Operations & Data Analysis	61.8	42.6	38.5	43.4
Research & Analysis	50.7	46.7	50.3	45.5
Total Life Sciences	42.2	39.5	55.7	59.0
Flight Experiments	12.7	14.0	24.0	23.0
Research & Analysis	29.5	25.5	31.7	36.0
Total Solid Earth Observations	151.4	149.4	132.2	74.4
Landsat-4	88.5	81.9	61.7	15.8
Extended Mission Operations		2.8	1.8	1.0
Shuttle/Spacelab	2.0	12.3	13.8	15.0
Geodynamics	23.4	22.9	26.2	28.0
AgRISTARS	21.5	14.0	15.0	-
Research & Analysis	16.0	15.5	13.7	14.6

TABLE 1 Continued
(in millions of dollars)

	1981	1982	1983	1984
Total Environmental Observations	104.1	133.0	156.9	163.0
Research & Analysis (less Space Physics)	76.8	(59.7)	(71.2)	(76.2)
Upper Atmosphere		20.5	27.7	29.6
Atmosphere dynamics		22.3	26.5	28.4
Ocean		16.9	17.0	18.2
Space Physics (Plasmas)	***	12.1	15.2	15.7
Shuttle/Spacelab	1.7	4.1	3.7	7.6
Operational Sat. Improv.		6.0	6.0	0.6
Earth radiation budget	20.3	24.0	24.0	15.5
Extended mission ops	-	16.1	22.4	27.4
Upper Atmos Research Satel	-	6.0	14.0	20.0
Other	5.3	5.0	-	-

NOTES TO TABLE 1

*These two lines did not include the same items in FY 1981 as in later years and so FY 1981 numbers are not directly comparable. See Tables 2 & 3.

**In FY 1981 ISPM was in the Physics & Astronomy program, and included a US spacecraft (since deleted) in addition to US experiments on a European spacecraft.

***In FY 1981 Environmental R&A did not include Space Physics, which was in Physics & Astronomy R&A (See Table 2).

Table 2

	1981	1982	1983	1984
Physics & Astronomy R&A	37.7	22.9	28.8	29.8
Space Physics sounding rockets	2.5	**	**	**
Environmental Observation Space Physics (Plasmas) R&A	*	12.1	15.2	15.7
TOTAL	40.2	35.0	44.0	45.5

*Space Physics (Plasmas) R&A was included in Physics and Astronomy in FY 81.

**The Space Physics (Plasmas) part of the sounding rocket section of the Suborbital Physics and Astronomy line in FY 1981 was transferred to Environmental Observations R&A for FY 1982, 1983, 1984 budgets. This part was $2.8 M in FY 1983, $2.5 in FY 1982, and estimated at approximately $2.5 M in FY 1981.

Table 3

	1981	1982	1983	1984
Suborbital Physics & Astronomy Sounding Rockets (less Space Physics, see Table 2)	22.5	24.4	27.0	27.7
Airborne*	4.5	17.5	17.6	18.9
Balloons	1.4	1.9	3.5	6.7
Applications Airborne	12.0	*	*	*
Total Suborbital	40.4	43.8	48.1	53.3

Applications Airborne included in Physics & Astronomy starting FY 1982. $12 M is estimated as the number for this item in FY 1981.

APPENDIX B

COMMENTS ON THE UNITED STATES SPACE SCIENCE SITUATION

The opening sections of the OTA Technical Memorandum* on space science give a brief survey of the many different aspects of space science. Then the memo goes on to say that planetary science is in real trouble because there are no new missions so that the scientists active in that field are without funds and without a future. They will soon be forced to turn to other things. And that is a fairly accurate picture of planetary science. But the memo stops at that point, leaving the impression that the other branches of space science surveyed in the opening sections are alright.

As a matter of fact, most branches of space science in the U.S. face a bleak future.

To illustrate a typical situation, solar physics can look forward to perhaps 12-15 months of new data at solar minimum following the repair of the Solar Maximum Mission (SMM). The Interplanetary Solar Polar Mission was to have been launched in 1984 for a look at the Sun--and conditions emanating from the Sun--at high latitudes, where no spacecraft has ventured before. But the U.S. spacecraft carrying the coronagraph was cancelled and the U.S. launch of the European spacecraft was postponed to 1986 - so that the mission is far less effective than originally planned and so far in the future that the U.S. research groups--even if they are participating on the European spacecraft--are disbanding for lack of support. The Solar Optical Telescope (SOT) is going ahead at a slow pace now, with a launch tentatively planned somewhere around 1988, assuming that there are no further delays in funding. The much touted opportunities for observations from Shuttle have not materialized - leaving the field of solar physics with little more than 12 months of SMM data for the rest of the decade. The fact that there are many crucial observations to be performed, as elaborated by intensive study and planning reports over the past six or eight years, seems to carry no weight. The space missions fade away as their time approaches.

Turning to magnetospheric physics, we can look forward to the Chemical Release Experiments of the AMPTE Mission, expected to be launched in 1983-84, in which a German spacecraft outside the magnetosphere is to release chemicals to be detected by the instrumentation on a U.S. spacecraft located inside the magnetosphere, giving direct measurements of the rate of entry of solar wind gases into Earth. But there is no real U.S. commitment beyond that. The OPEN Missions to study plasma waves, etc., in the magnetosphere and surrounding solar wind are moving

*Space Science Research in the United States: A Technical Memorandum by the Congressional Office of Technology Assessment (September, 1982)

along with a launch tentatively planned for 1991 or 1992, perhaps. The Shuttle and associated Spacelab experiments have not materialized. It may be ten years before there is a new mission. It is just not possible to keep good physicists interested in space experiments when the future is so far away and so uncommitted.

The field of X-ray astronomy looks forward to flying a less expensive version of the HEAO-II X-ray telescope on the German X-ray spacecraft to be launched in 1986. The X-ray Timing Explorer (XTE) at about the same time is the only new U.S. mission firmly in the pipeline. The large, high resolution X-ray telescope, Advanced X-ray Astrophysics Facility (AXAF) is only a dream that could not materialize before 1990, at the earliest. The initiatives are passing to the Japanese and the Germans, who have committed themselves to four X-ray space missions in the coming years. It is ironic that the U.S., having brought the science of X-ray astronomy to a peak with HEAO-II, should now sit back, unwilling to commit capital, while other nations press on from the summit that we established by an investment a decade ago in our own space science. As in the other fields already cited, the X-ray community is frustrated year after year by a refusal of the U.S. to commit itself to new missions. Shuttle opportunities, once presented in glowing terms to the scientific community, have failed to materialize. Postponement into the next decade is the word of the day, which leaves a strong doubt that the field will go ahead in the U.S. at any time in the forseeable future.

In the field of gamma-ray astronomy, France and the U.S.S.R. have cooperative plans for an orbiting gamma-ray observatory, to be launched some time in 1983-1984. It will be a simple affair, but capable of doing some interesting science. The U.S. Gamma-Ray Observatory (GRO) will take a more precise and detailed look at the gamma-ray sources in the sky, but it has now been pushed back to a tentative lauch in 1987-1989, at the end of the decade. It is not clear how one can sustain interest and scientific capability in the interim, particularly when the scientific community is aware that a further delay in the launch of the U.S. GRO may come with any new annual budget cycle, as have the endless delays in the past.

Taken together, these plans do not add up to much for space science in the U.S. in the next ten years. Three or four missions among as many different fields of inquiry in a ten year period are not effective for getting at the crucial issues. All of the major fields of space science are focussed on important discoveries and critical issues in the active universe around us. Progress in each subject is paced by observations from spacecraft. Each subject is propelled by the vigor and enthusiasm and past successes of a small group of U.S. scientists. If the U.S. does not have some new starts and rapid progress in space missions in the very near future, U.S. space science will wither away. Space science will pass into the hands of other countries with more vigorous and determined approaches (Germany, Japan, France, USSR). Not a word of this, beyond planetary science, is to be found in the OTA memo.

Another point is that the memo presents the annual budget

for NASA space science, (Figs. A-2, A-3, A-4) showing the general downward trend over the years and small upturn at the end for 1983. The figures make the point, but it should be emphasized that the small upturn for 1983 reflects the delay of launch dates, particularly SOT, Galileo and the Space Telescope. The actual money going directly into scientific research outside NASA is not larger in 1983 than in previous low years. U.S. scientific teams are in the process of disbanding today because the launch dates for the spacecraft with which they are concerned have been pushed so far in the future that: a) the dates are not always believable; and b) the support for the teams has been turned off by NASA to save money in the interim.

A willingness to make major capital investments in the future is as essential for effective space science as it is for most other serious activities. Short term policies, based on momentary political winds, make effective science impossible. It was the NASA investment in the sixties and early seventies that placed our country in the prestigious position of number one in space and in space science. Unfortunately, the causes of our success were not perceived in all quarters, so that the late seventies and the first two years of the eighties saw: a) little or no new investment; b) an unwillingness to support the continued operation and analysis of the scientific space missions built with earlier investments; and c) a tendency to reverse policies every 12 months.

The result is that the U.S. has dropped out of most fields of space science for the rest of the eighties. Worse, the stochastic policies of the past few years have created a credibility gap. The scientific community has learned that no matter how well conceived, no matter how far along, and no matter how internationally based, a space mission can be cancelled at any point at the blink of an eye. One has to remember that the motivation for scientists to contribute their time and effort to a space mission is not monetary profit, but scientific success. And scientific success requires a firm commitment to go ahead with space missions.

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December, 1982

Mr. VOLKMER. Thank you very much. I appreciate all of your testimony here and now we'll proceed with questions. Mr. Bateman, do you have any questions?

Mr. BATEMAN. No, Mr. Chairman.

Mr. VOLKMER. I reviewed your statements last night and I was sorry I wasn't able to be here for the start of the session but I had another matter I had to attend. I generally get the feeling from all three that we're having what I would call an erratic approach to planetary exploration and also research and analysis here on Earth as to the matters that need to be dealt with. Is that a correct statement or not?

Dr. DONAHUE. Yes, I'd say that's a fair characterization of the approach to planetary exploration during the past several years as I tried to say in my statement and I think Dr. Hinners also indicated. I hope that we've begun to stamp out that kind of wild oscillation in the planetary program and are beginning a period in which some measure of stability will reappear in the planetary exploration program. Others may want to comment also.

Dr. HINNERS. I concur with that, Mr. Chairman.

Mr. VOLKMER. All right. Now, as I understand one of you proposed that we add $50 million a year or something like that more-or less. Is that correct?

Dr. HINNERS. That's correct. That was for the class of spacecraft that we call a planetary observer——

Mr. VOLKMER. Yes.

Dr. HINNERS [continuing]. Similar to the explorer program which would provide the continuity in planning and implementation of exploration of the inner planets.

Mr. VOLKMER. And that would give us 1 every 3 years then?

Dr. HINNERS. Every 2 to 3 years.

Mr. VOLKMER. Every 2 to 3 years. With that type of program then you would still have to have the budget for the research and analysis continuation; is that correct?

Dr. HINNERS. That's correct.

Mr. VOLKMER. So your program would be in addition to that?

Dr. HINNERS. That's right. There were four components of the overall program.

Mr. VOLKMER. Yes.

Dr. HINNERS. The research and analysis base, the mission operations and data analysis, the planetary observer, then what was called the Mariner mark II for the outer planets missions was the fourth component.

Mr. VOLKMER. Right. Would you be able to keep the basic teams together for the research and analysis that we have with one mission every 2 or 3 years?

Dr. HINNERS. Yes. If you look at the combined planetary observer and the Mariner mark II programs, the launch frequency is every 1½ to 2 years. And we have in that plan the build up the research and analysis program combined with the flight probe such as it would accomplish that objective.

Mr. VOLKMER. As I understand it this is being discussed with NASA?

Dr. HINNERS. That's correct. This week we did submit our final draft to the NASA advisory committee. We have had discussions with the NASA Office of Space Science and Applications.

Mr. VOLKMER. OK. Would anyone like to tell me right now what we have facing us as far as in the immediate future and delays on the space telescope and other programs? What is, what I would say in layman terms, the health of the space science community right now?

Who wants to take that?

Dr. HINNERS. Probably nobody.

Dr. DONAHUE. I will.

Mr. VOLKMER. As I understand it some of the universities may be disbanding groups because of lack of funds plus lack of something actually to work on?

Dr. DONAHUE. We're getting to that stage, yes. I know of many groups that were formed at the beginning of the space program that are seeing the end of funding this year. They include space science groups that will be needed if the planetary program at NASA revives in the way suggested by the Solar System Exploration Committee. It's not just in planetary science either that this condition exists as Dr. Krimigis indicated. There are other areas of space science in which the United States has been the leader in the past such as high energy astronomy, space physics, and solar physics in which we are lagging now and in which other nations are taking the lead. There are research groups at universities and elsewhere that have been active in these research areas that are threatened with extinction.

Mr. VOLKMER. Let me give you a what if. These are the things that face us. You know we all would like to have more money here and more money there, but we are limited. But what if you had $10 million to add to the NASA budget, where would you put it? I know you added about $17 million but let's say you only add $10. Where are you going to put it?

Dr. KRIMIGIS. Well, clearly planetary research and analysis was cut down this year from what the Congress appropriated and that would have to be the highest priority for the $10 million that you have just suggested.

Mr. VOLKMER. Would the 1983 level on that be sufficient?

Dr. KRIMIGIS. We don't feel so, Mr. Chairman.

Mr. VOLKMER. Would you put the whole $10 million in research analysis and planetary exploration?

Dr. KRIMIGIS. We would have to think hard about that. It's quite possible between that and the $2 million in the area of advanced technology development for the OPEN program where, as I indicated, there are university affiliated teams who need to continue their existence. If that $2 million is not there they are likely to be disbanded. So we have good places to put those kinds of funds.

Mr. DONAHUE. $8 million for planetary and $2 million for OPEN.

Dr. KRIMIGIS. I second the motion.

Mr. VOLKMER. I will take note of it. Now, the other thing that sometimes faces the ranking minority member here, one who I know feels very strongly about holding down on the budget, is that if you add 10 you have to subtract 10. Now where would you subtract 10 from NASA?

Dr. DONAHUE. I pass.

Mr. VOLKMER. Dr. Hinners do you want to pass? You can pass.

Dr. HINNERS. I'll pass on that.

Mr. VOLKMER. Dr. Krimigis?

Dr. KRIMIGIS. I'll pass also, Mr. Chairman.

Mr. VOLKMER. I want you to see our problems also. Sometimes something has to give to add. I guess you all briefly addressed a little bit of the problem, we don't know how serious, on the space telescope. Does anybody wish to comment on that as to the technical problems? The implication of the delay?

Dr. HINNERS. I could say a few words on that, Mr. Chairman. I'm not in a position to comment in detail. The delay which I've heard discussed does give us an opportunity, I think, to look to be sure that our test and verification program for these very complex scientific instruments is structured correctly. It's been on a tight schedule and I think if the schedule is going to change we want to be sure that we take advantage of it at the same time that it's causing us problems to be sure we have the right test program structured.

Mr. VOLKMER. In other words, the fact that this did occur may be of some help in the future?

Dr. HINNERS. I'm referring specifically to the space telescope in that sense.

Mr. VOLKMER. You mean that we may not have other very scientific, very precise-type instruments that may have to be tested out in the future on other programs that could run into the same problems?

Dr. HINNERS. That's a different thrust that you're talking about. I think what we are learning in that sense and have seen is that the instrumentation and the technology involved in a lot of these frontier science programs now is very complex and that we do have to lay them out very carefully with the proper advance research programs to define that technology and be sure we're on a good footing when we start off.

Mr. VOLKMER. In other words——

Dr. DONAHUE. If I may I would like to comment on that question too.

Mr. VOLKMER. Yes.

Dr. DONAHUE. There is a tendency when a program suffers a delay such as has been suffered by the Galileo mission and now probably will be undergone by space telescope to keep the schedule for delivery of the instruments rigid and to insist that the scientific instruments be delivered on the original schedule while work on the spacecraft continues. It seems to me this is a shortsighted policy because usually the cost of further work on these instruments amounts to peanuts compared to the cost involved in getting the spacecraft delivered. You could bring about some major improvements in the testing and bringing flight instruments up to specifications and that's true not only of the space telescope program, but, for example, of the Galileo hardware.

Mr. VOLKMER. Now, in relation to the space telescope program I believe there were some statements made about the Institute. Can somebody tell me the progress presently with the Space Telescope

Science Institute in preparation for the space telescope operation? Is it in good shape?

Dr. HINNERS. I could comment on that, Mr. Chairman. The Space Telescope Science Institute, Johns Hopkins, and the Goddard Space Flight Center have the joint responsibility to be sure that we're ready for telescope operations. In the initial startup days of the Institute there were rough phases to overcome. My assessment is that in the last several months that we are settling down to a mutual understanding of what our individual responsibilities are and that we are making good progress now in getting set for the operational phase. I'm encouraged with what I've seen recently.

Mr. VOLKMER. Most of the difficulties then are overcome?

Dr. HINNERS. I think the difficulties occasioned by lack of understanding of individual roles. I think that is overcome. I think we still have technical challenges in getting the ground softwear systems ready for operation, but we're working on those jointly as a team.

Mr. VOLKMER. You have no problem reaching the—being prepared, let's say, in 1985?

Dr. HINNERS. I don't foresee any.

Mr. VOLKMER. Go back again to the $50 million a year for planetary and building up so you have a more stable planetary program. Now, what about having a space science budget divided differently than we presently have it and say have a core amount of money that's to be protected at all costs, in other words a set amount, and this would not go up or down very much at all. This would be for continuing activities, for data analysis, for Explorer-type missions, and then have another amount that is usually larger than that amount but would fluctuate. It would depend on the amount we could get in the budget for mission development.

What do you think of that?

Dr. DONAHUE. It's an interesting idea. A commitment to stability in support of space research is badly needed.

Mr. VOLKMER. You're going to have more stability on what I call the lower end of the present budget on the mission operations, analysis and research.

Dr. DONAHUE. I did mention in my statement the formation of a panel by NASA, a panel of representatives of the academic community and the agency to address this agonizing question of stability in support of space research at the universities. And the sort of scheme you mention is certainly one that will be considered, among others to bring about stability in support of space research at the universities. So it's an interesting idea.

Mr. VOLKMER. Dr. Hinners, I have a question here that another member of the committee couldn't be here would like to have me ask for him. Would you comment on the administration's request in regard to the areas of which you testified to as compared to the SSEC's recommendations?

Dr. HINNERS. The budget submitted by the administration for fiscal year 1984 is in large part responsive to the SSEC recommendations up to this point. In other words, the Venus radar mapping mission we did put as the highest priority scientific objective in the 1984 submission. The research and analysis part of the budget is not yet back to the level which we thought would be the best stabi-

lizing program which is roughly comparitive to the fiscal year 1981 level.

Mr. VOLKMER. In NASA was there any trade-off made in this area? In other words, you get the Venus radar mapper, but you have to cut back someplace else?

Dr. HINNERS. No, there was not.

Mr. VOLKMER. Let's say the amount in for research and analysis and for mission operations and data analysis in the planetary explorations continues and let's say that in 1984 there is no additional amounts put in and then in 1985 you get approximately the same amount, or a little less again. Where does that put us as far as Venus radar mapper, as far as research analysis and data operations? Along with the Explorer programs et cetera that we presently have ongoing?

Dr. DONAHUE. In sad shape.

There are scientists who will be needed to analyze the data obtained by the Radar mapper mission whose funding will cease before the VRM ever flies. They won't be around when we need them—they'll go elsewhere to do research.

Mr. VOLKMER. You just can't go out and pick people up off the street and say we want you to do this and we'll pay you.

Dr. DONAHUE. That's not the way I'd like to run the shop, no sir.

Dr. KRIMIGIS. Ladies and gentlemen, for example, the $5 million that we have identified as the shortfall in the research and analysis below the fiscal year 1983 level roughly means about a hundred scientists because a typical grant in universities are $50,000 to $100,000. So, we're talking about essentially cutting the funding of about this many active science workers in the field. So, those funds are really high leverage, as I said in my testimony, with regard to university research groups and are very essential.

Dr. DONAHUE. If I may add another comment, the lack of funding for this field of research means that the young people are no longer coming into the field. Graduate students are not appearing to work in the space sciences, young assistant professors can't afford to devote their time to do research in this area. So the few research groups that continue to exist are headed by old gray heads like myself who are marching on to retirement. Five years or so from now you'll see all of us disappearing over the hill, with nobody to replace us, if this trend continues.

Mr. VOLKMER. What has been the impact of the decline since 1981 in the research, mission operation, and analysis budgets, in real dollars? Have we lost people?

Dr. KRIMIGIS. We certainly have, Mr. Chairman. I'm not sure we have the statistics to back that up, but speaking from my own experience, for example, in the involvement that I've had with the Voyager program, the plan was to involve a large number of scientists who would avail themselves of the data that were acquired and after 1 year of funding those funds vanished and all the people were cut off, and we're talking about probably 50 to 100 investigators in this area who are doing other things.

Mr. VOLKMER. We have fewer individual investigators, is that correct?

Dr. KRIMIGIS. There were no funds to support access to the basic Voyager data set by the wider scientific community. NASA initial-

ly designed such a program, called the outer planet data analysis program, but it was only funded for a year. The cuts were then implemented and these people disappeared and it is truly a shame that we have tremendous data set which is there and we have made a tremendous investment as a nation going to other planets, and yet we're not taking advantage of the data and analyzing it fully.

Mr. VOLKMER. Do you have any questions, Mr. Bateman?

Mr. BATEMAN. If my premise is a correct one, to the extent we maximize the practical application of the fruits of basic research it makes it easier for those of us sitting here to obtain more funding for basic research. In that context do you have any observations you would like to share with us on the reductions in the budgets in the NASA for technology applications activities?

Dr. HINNERS. I'd like to take a stab at that. Much of the basic research that we've been referring to here today on the surface does not appear to have immediate, what I call practical, applications. What it does is two things in my view. No. 1, it is a training ground for scientists, technologists, and engineers. Many of whom do go on to other areas and directly apply the talents they have acquired into what we might consider more practical applications. That's a direct feed-in to the graduate students you've been hearing so much about. The other is that applications eventually depend upon having built at sometime in the past a store of basic knowledge from which one then draws. Space science, as so many other basic research programs, is building that storehouse of knowledge from which we will draw in the future, not being able today to predict just which piece of information is going to be the one which turns out to be valuable. But we do realize that it's that strong base we need to build. That is what I like to think of as a contribution of the space science.

Mr. BATEMAN. We certainly are in accord, I am with everything you've said, and yet in a real world the more the body politic is aware that we have made withdrawals from that deposit of knowledge and put it into circulation, if you will, or into application, it makes it easier to increase that storehouse of knowledge through more basic research. I for one have been a little disturbed that, as we throw figures around up here (though it's essentially a modest amount of money), there has been a reduction in the technology applications. I just can't believe that it becomes a lot easier for those of us who have the responsibility for the appropriation of funds for basic research. If our constituency is made aware that there is an acceleration of applications, and that that modest amount of money perhaps makes it possible for you to get larger sums of money for the ultimate enhancement of the base of knowledge. That was the point of my question. Obviously, it goes beyond the technical scope of why you're sitting there today or why we're up here today, but I think there may be a connection between that which is doable in the areas of your primary concern and the extent to which we maximize the utilization and application of the existing technology.

Dr. HINNERS. I agree with that, Mr. Bateman.

And there are many examples we can find in getting that direct——

Mr. BATEMAN. Oh, yes, indeed.

Dr. HINNERS. The study of the Earth's atmosphere now is being approached on a global scale and many of the people involved in that have been involved in studying the atmosphere of Venus where they were forced to take the global look initially rather than looking at individual pieces and they are now applying that methodology to looking at the Earth's global circulation, the impact of volcanic gases on climate, coming up with a computer model and the theories behind it to help us understand how the Earth's atmosphere is evolving.

Mr. BATEMAN. I think there's an exciting story that can be told in terms of the practical applications of the knowledge and data that has been accumulated and I for one want to see it go forward in dramatic ways with our basic research. It just makes it a lot easier if, for the lack of a better word, you have better PR in terms of what has already been accomplished that is tangible and demonstratable to people who don't have you reminding them as often as you remind us of what the benefits of basic research are.

Mr. Chairman, if time permits, there's another question I'd like to——

Mr. VOLKMER. The Chair yields the gentleman additional time.

Mr. BATEMAN. In addition to the appropriation budgetary function for which we are here primarily today, there's an oversight responsibility. I wonder if you have any insight you could share with us as to particular NASA facilities, subagencies, activities, which you think have demonstrated a superior performance in terms of results for dollar expended. I'm not asking you to say who's wasting money but who is to be commended for the excellence of the manner in which they are performing.

Dr. DONAHUE. I would single out the Goddard Space Flight Center.

Mr. BATEMAN. Is that the only one?

Dr. KRIMIGIS. If I may make a comment, Congressman Bateman. A year or so ago NASA launched an explorer spacecraft called the solar mesosphere explorer which was actually managed by a three man team from the Jet Propulsion Laboratory and was designed, built, and operated from the University of Colorado. And I believe that in the past 10 years that has to have been the most cost effective program that NASA has put together in terms of science return for the money. I believe the expenditure was only $17 million.

Mr. BATEMAN. Could you repeat for me the name of the program?

Dr. KRIMIGIS. Solar mesosphere explorer, and was as I said primarily designed, conceived, and built at the University of Colorado.

Dr. DONAHUE. The control center in fact is in Boulder. The satellite is controlled from Boulder, Colo., by teams that consists of a supervisor and two students, controlling and sending up commands to that satellite and the whole thing works very well. It's being operated by the laboratory for atmospheric and space physics at the University of Colorado under the directorship of Prof. Charles Barth.

Mr. BATEMAN. You know your mention of the University of Colorado leads me to ask this question. As in any area there are always pioneers in any given field, and certain institutions I'm sure were

earlier on into space programs, much earlier than others. Do you feel that we have been expanding the involvement of universities in the area of space exploration and research at a satisfactory pace or are we tending to concentrate on the same pioneers who always are earliest into the program? Are we diffusing participation or are we concentrating participation among the same cast of players?

Dr. KRIMIGIS. I would say, Mr. Bateman, that we are expanding in the sense that there are other institutions that have become involved. However, the total amount of money that is available to be distributed has shrunk to the point that groups that were in the past involved are no longer. So to add to that there is the issue of how much management can a small university tolerate on the part of the Government and my colleagues here may disagree with me, but I think it's fair to say the feeling is that perhaps if there was not so much management and if the universities were sort of left alone to take some risks with their designs and their programs that the overall costs would be less and perhaps one would get more science for the dollar.

Mr. BATEMAN. Is there any other or different view of that?

Dr. DONAHUE. You certainly do not see new research groups at universities getting into space research these days. I've kind of sensed in the last several years that because of the infrequency with which we've been launching missions to space that there is a perception this is no longer a field on the frontier of research. So we're not seeing new groups at universities growing up, quite the contrary. Some of the old, well-established research teams are growing weak and disappearing. I hope that this is the year that we see this trend reversed.

Mr. BATEMAN. I'm sure that we all do. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you. First, does the gentleman from Florida have any questions?

I have a few other questions yet. The satellite sent up by the University of Colorado was the Solar——

Dr. KRIMIGIS. Solar mesospheric explorer.

Mr. VOLKMER. Dr. Hinners, you analyzed that whole program?

Dr. HINNERS. I agree with what Dr. Krimigis said about that. It is a very well run, high focused program and in fact Dr. Barth was one of the great stimulators on the Solar System Exploration Committee for the go small approach and much of his thinking is involved in the structuring of the planetary observer program.

Mr. VOLKMER. So that went into the SSEC recommendations, basically, what they learned from that program?

Dr. HINNERS. That's correct. It causes one to force changes in culture.

Mr. VOLKMER. Now we're talking about the scientific culture.

Dr. HINNERS. And engineering. We're dominated by those of us who grew up in the early sixties when business was done in a certain mode, when there were very few centers for space activity. With the experience that has been built up over the past 20 years with the increased capability of spacecraft, with today's computer technology, with the ability to shift information and data around the country with relative ease, we've got to change maybe the way we do things. And now it's quite possible to shift tracking informa-

tion out to the University of Colorado. It needn't stop at Goddard or Johnson Space Center. In fact we do, the information comes to Goddard we pipe it out to the University of Colorado. So certain missions can be done very well in that mode now. You've got to break some thinking chains to get there. That's the challenge I think of today that management is taking. Get people thinking in new ways of doing business.

Mr. VOLKMER. What about the new way—smaller like the planetary observers versus the complex and large spacecraft with the large and complex payload?

Dr. HINNERS. That's right. It took us 2 years of working with the community and with NASA to get there. And the whole attitude changed in that 2 years. Initially it was the perception that it was not a strong good science program that could be done in that mode. Most of us involved in the activity now believe that there is.

Mr. VOLKMER. Is this the same type of thinking that led us to the Venus radar mapper rather than the VOIR?

Dr. HINNERS. That's absolutely correct. The initial VOIR's had everything on it. There had been in retrospect insufficient pressure to drive the cost of that down. I think we've probably taken it about as far as one would dare go.

Mr. VOLKMER. In other words, we can't reduce costs another 50 percent and get only a 10-percent loss in the science. You can't get down to $50 million and say OK, we're going to shoot it up and just send it on to Venus.

Dr. HINNERS. I believe we're about there. I always believe it's best to shoot for the hard to do. But don't try to do what really might be impossible.

Mr. VOLKMER. And you don't always have to have the 100 percent? That is possible, is that correct?

Dr. HINNERS. In certain areas the 100-percent syndrome does exist. There are certain missions such as the space telescope where the investment is so great that those of us working on it say we cannot afford a failure. You've got the tendency then to want to make everything completely redundant and absolutely 100 percent and say OK we'll at least work on 99.99. On the other hand we do need to get in a mode where we take more risks on the small payloads. Now, the shuttle for many many years has been advertised as a vehicle which would let us put up cheap space science experiments. We are not there yet. We need to drive that one hard. I believe the agency has finally realized that it had better get there also and be willing to take a 0.8 or 0.9 success for those kinds of experiments which you do in a quick mode and let the investigator take the responsibility in large part.

Dr. DOHAHUE. May I comment?

Mr. VOLKNER. Yes.

Dr. DONAHUE. I think we have to be a little careful. VOIR was a very good mission. And we gave up some good things when we gave up VOIR. Let's face it. There is no free lunch I think the spatial resolution that will be obtained by the Venus radar mapper is at the limit of what is acceptable—that is a resolution of 1 kilometer. I wouldn't like to see that specification relaxed very much more. VOIR would have produced maps with considerably higher resolution. And it also had a mode of mapping which was called the high

resolution mode for which there is a good scientific justification; and I'm not sure we'll be able to obtain that with VRM. There would have been atmospheric experiments carried on the VOIR mission that were not related to the mapping mission but they were experiments that were well worth performing.

Whether VRM is more cost effective or a more cost effective way of doing science than VOIR or this new mode of carrying out solar system exploration is more cost effective than the old one or not, I'm not sure. But they are certainly more affordable ways of doing the job and therefore a more realistic way of going about it. They represent the kind of scientific programs that we may be able to sell. But we give up something when we give up missions with the scope of VOIR and I think that missions of that scope, of the scope of Gallelo and Voyager still have to be carried out eventually if the needs of science are to be met.

Mr. VOLKMER. But not all programs.

Dr. HINNERS. Yes. We got into a trap of making every one of our planetary missions a mission of the Voyager and Gallelo type, and I hope we're out of that trap now.

Mr. VOLKMER. Now, to get to a little different area. As I understand it the Field Committee recommended several prerequisites for new programs. Starting with new instrumentation theory, computers, laboratory astrophysics and technical support for Earth-based observatories. Now, do you feel that these type of things should be funded in a program before a new program such as the AXAF is fully funded?

Are there any prerequisites in that sense?

Dr. DONAHUE. Not in that sense.

Mr. VOLKMER. In other words, the chicken and the egg. Which comes first.

Dr. DONAHUE. For the most part I think those programs are badly needed and they ought to be in place. They're not prerequisites in the sense that you can't mount a meaningful AXAF mission without them, but to maxamize the return from the AXAF mission——

Mr. VOLKMER. You have to have those things in place there.

Dr. DONAHUE. They ought to be in place. Attention to needs of this sort: for instrumentation, for computers, for laboratory measurements and so forth, is badly needed. That's the kind of base program that we've all been talking about today and I make a strong recommendation to this committee that it help NASA get this sort of competence in place.

Mr. VOLKMER. One last question for Dr. Krimigis. I have one question specifically for you.

If you disagree with my first statement that I'm going to make here in my assumption, let me know that to begin with, all right? The assumption is that, unlike other disciplines covered under space science, such as planetary exploration or astronomy, the scientists involved in the study of the Sun, the solid Earth, its extended atmosphere, including the solar wind, the Earth's magnetosphere, ionosphere, and the atmosphere, including weather and climate on Earth, including oceans as well as the land, all of which are more or less connected through physical cause and effect, now

these scientists, those that are studying those things, do not form an identifiable or inherent community?

Dr. KRIMIGIS. That's correct.

Mr. VOLKMER. They do not carry and perceive well defined goals in a common effort?

Dr. KRIMIGIS. The goals actually are there because the Space Science Board, in fact, Dr. Donahue, will tell you has a committee which is called solar and space physics which addresses these issues. And in fact, that committee has provided the strategy for what NASA should be doing in the 1980's along these lines. However, because of I guess organizational difficulties the discipline per se does not have strong advocacy within NASA.

Mr. VOLKMER. Maybe Dr. Donahue—do we have a strategy? Do we have a strategy for the future in the area of solar exploration?

Dr. DONAHUE. The strategy is there and one problem that Dr. Krimigis pointed to is a problem of administration and giving that discipline high visibility within the agency. But I think there is another problem and that is the problem of—this is really a disciplinary kind of science and interdisciplinary programs at universities or wherever always have difficulty getting support for the recognized research communities and I think it would be very useful if that solar terrestrial physics community you talked about could somehow get its act together and some agreement about the plans of programs that they would like to see in place and which are really needed could rise to the surface.

There is a problem there. You identified a problem area and it needs our attention.

Mr. VOLKMER. OK. And I'm sure the Science Board is hoping somebody takes the lead in getting the attention that needs to be gotten. Somewhere there has to be some jelling.

I've completed my questions.

Mr. NELSON. I have just a quick one here. Dr. Donahue, you had said that your Board wasn't ready to take a position on a space station. Are you ready to take a position on a fifth orbiter?

Dr. DONAHUE. To what extent is the issue of the fifth orbiter is not a space science issue?

Mr. NELSON. How would you get items up into space if you don't have a vehicle?

Dr. HINNERS. I'd probably get myself in trouble. What our science experiments require is observing time. The observing time in the usual shuttle mission of 5 to 7 days is just too short. Much preferable would be observing times within shuttle capability of 3 or 4 weeks. In which case you wouldn't have to refly the same experiments as many times to get the equivalent observing time, particularly in astronomy. So from my limited perspective, if we could get increased stay time in orbit for some of these observing experiments we would increase the efficiency of our science operations. Now that means that while the shuttle is on orbit it is not available for launches of other payloads. And how that translates into the total shuttle demand I don't know. But it does get into that whole argument of how many shuttles does one need to conduct the program.

Mr. NELSON. My answer to the question you have just postured is that your need more than four orbitors to do all that. And particu-

larly, since all the defense payloads have the priority and if you add to the fact, the Lord forbid, that one of those should go out of operation, I'll let the conclusion be drawn by my silence.

Thank you Mr. Chairman.

Mr. VOLKMER. I have one other question. Mr. Nelson mentioned the shuttle being in orbit longer and that brings up my question, the need for a space station. Does anybody wish to comment upon alternatives other than a space station?

Dr. DONAHUE. Well, it certainly isn't us yet that space science programs need a manned space station. Most of the needs we have been able to identify can be served by the space shuttle augmented with an adequate upper stage. On the other hand, there are other obviously many disciplines that would benefit from long stay times on orbit. For example, the solar optical telescope, the space infrared telescope facility would be much more exciting and useful facilities if they were on orbit longer than one shuttle flight. Some means of refurbishing, reservicing facilities while on orit would be very useful. That isn't to say you need a space station to do that. On the other hand, there are some requirements, some needs that only a space station, as far as we could see, would really be able to fill. Such as constructing large structures in space. At present we don't have any missions that call for things like that in the space science program and so we haven't yet been able to identify any clear need for a space station to——

Mr. VOLKMER. We still haven't defined a space station, have we?

Dr. DONAHUE. No. The agency is working with due deliberation to decide just what a space station might look like. And the Space Science Board is cooperating with them in trying to set forth the science requirements.

Mr. VOLKMER. Right now we can't say either we don't need a space station in the future.

Dr. DONAHUE. No. I certainly am not prepared to say that the Nation should not have a space station, not today. There may be reasons other than scientific for building it. In fact I don't think that many people would hold that the reasons for building a space station are scientific.

And we do not have the foresight and wisdom to identify all the benefits that might accrue to space science if a space station were indeed available.

Mr. VOLKMER. I want to thank all three of you for being here today.

The committee will stand adjourned until tomorrow at 1:30 p.m.

[Thereupon, at 3:46 p.m., the committee recessed, until Thursday, February 24, 1983, at 1:30 p.m.]

. [The following letter was provided after the hearings for insertion in the record.]

Columbia University in the City of New York | *New York, N.Y. 10027*

DEPARTMENTS OF ASTRONOMY AND PHYSICS
Columbia Astrophysics Laboratory

538 West 120th Street

March 30, 1983

RN 83-59

Dr. Hans Mark
Deputy Administrator
Code AD
NASA Headquarters
Washington, D. C. 20546

Dear Hans:

I am writing to you because I understand that you and Mr. Beggs recently testified before Congress to the effect that support for the analysis of the data from the Einstein Observatory should be decreased because this is a completed mission. With the assumption that a space science mission has as its primary objective the collection, analysis, interpretation, and dissemination of data relevant to the astrophysical problems the payload instruments were designed to address, I must respectfully disagree with your testimony.

I feel very strongly that the support for the analysis of the data from the Einstein Observatory should be continued for at least the next 4-5 years at its present level. Typically in observational astrophysics, an astrophysicist will spend 10-20 times as long analyzing data as collecting it. For example, a typical ground-based project would require 2-3 scientists spending 1-2 weeks at an observatory followed by half a year of analyzing, modelling, and publishing the results of this observation. Since the Einstein Observatory made observations continuously for a period of 2 $\frac{1}{2}$ years, one should then expect to devote 200-250 man years on the analysis of the data. The Einstein data is every bit as sophisticated as the typical optical or radio data and it is unrealistic to think that it can be analyzed in any less time. It would be wasteful of a major national scientific resource, which was obtained at great expense, to curtail the data analysis support before the analysis is completed. As I indicated above, this will take 4-5 years of effort at the present level.

I understand that as a result of direct petitions from the scientific community, the relevant committees in the House have supported additional funds for the Einstein Observatory data analysis for FY84. We hope that the Senate will also support these funds. I hope that in the future NASA will request adequate funds for these activities in its presentations to Congress so that those of us in the scientific community will not find it necessary to appeal directly to Congress for adequate funds for the support of NASA projects. At the very least it would seem desirable that, in the future, NASA officials not offer testimony that contradicts the wishes of the scientific community.

Sincerely,

R. Novick
Professor of Physics

RN:tz

1984 NASA AUTHORIZATION

THURSDAY, FEBRUARY 24, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to adjournment, at 1:42 p.m., in room 2318, Rayburn House Office Building, Hon. Harold L. Volkmer (chairman of the subcommittee) presiding.

Present: Representatives Volkmer, Brown, Nelson, Dymally, Lujan, Walker, Bateman, and Chandler.

Mr. VOLKMER. In today's session, we conclude 3 days of hearings on NASA's space science and applications programs.

Three very distinguished witnesses have agreed to testify as a panel on NASA's applications programs. As I said 2 days ago, when Dr. Edelson presented NASA's budget and program, our concerns are not so much with technology development as with final application of the technology. The interface with users or customers seems to need a little more attention.

For example, in the advanced communications technology satellite mission, we want to know exactly how this is going to be received by industry. Another example is in the remote sensing area, where it seems that there may not be a vigorous enough user community to support commercial operation of Landsat. This may be in part because not enough work has been done to demonstrate how useful information can be extracted from Landsat data.

We will begin by hearing from Mr. Willis H. Shapley, member of the Space Applications Board, National Academy of Engineering, who will present testimony on behalf of the Board. Next, Mr. Emanuel Fthenakis of Fairchild will testify on communications applications. And finally, Dr. John Yardley and Mr. James Rose, both of McDonnell Douglas, will testify on materials processing in space. As a Missourian, I respectfully thank you both for appearing here today.

Gentlemen, we would like for you to testify as a panel; you all have your testimony prepared, and that will be made a part of the record. You may either summarize your testimony, or you may review it completely, however you see fit. We can start now with Mr. Shapley.

[A biographical sketch of Mr. Shapley follows:]

WILLIS H. SHAPLEY

Mr. Shapley was born in 1917 in Pasadena, California, and was educated at Harvard College (1934-36) and the University of Chicago (1936-42), where he was a graduate fellow and research assistant in political science.

He entered government service in 1942 with the Bureau of the Budget, Executive Office of the President, where for twenty-three years he specialized in research and development, national defense, and space programs, becoming, in the 1960s, Deputy Chief of the Military Division and Special Assistant to the Director for Space Program Coordination.

In 1965 Mr. Shapley became Associate Deputy Administrator at NASA, in which position he served for ten years as the principal senior assistant to the Administrator and Deputy Administrator of NASA.

Since retiring from his NASA position in September 1975, Mr. Shapley has been a consultant to the Administrator of NASA, the American Association for the Advancement of Science (AAAS), the Office of Management and Budget, the Office of Science and Technology Policy, the Office of Technology Assessment, and other organizations. For the AAAS, he has been the author or principal author of the annual AAAS reports on research and development, beginning with Research and Development in the Federal Budget: FY 1977, published by the AAAS in August 1976, and continuing through Research and Development: AAAS Report VII, published by the AAAS in June 1982. He has been a member of the Space Applications Board since July 1978.

Mr. Shapley has received the Bureau of the Budget Exceptional Service Award (1963), the Rockefeller Public Service Award (1956), NASA's Distinguished Service Medal (1969), and the Career Service Award of the National Civil Service League (1971).

STATEMENT OF WILLIS H. SHAPLEY, MEMBER, SPACE APPLICATIONS RESEARCH BOARD, NATIONAL RESEARCH COUNCIL

Mr. SHAPLEY. On behalf of the chairman and members of the Space Applications Board, I want to thank you for your invitation to present the views of the Board on the Nation's programs directed at practical uses of space systems by the civil community.

Mr. James Plummer, who is just completing his term as chairman of the Space Applications Board, regrets that he is not able to be here today. He and the Board have asked me to appear here in his stead. My statement has been prepared in collaboration with him and is intended to present the consensus of the Board.

As you requested in your letter to Mr. Plummer, I will comment briefly on the 1984 budget request for NASA's space applications activities and address the areas you identified as of concern to the subcommittee.

The Board recognizes that the 1984 budget is an improvement over the budgets presented to Congress in recent years. The complete moratorium on new starts has ended. The administration has now given its approval to the advanced communications technology satellite program which this subcommittee and the Congress approved last year. There seems to be a green light for moving ahead with the upper atmosphere research satellite, which has applications as well as scientific significance.

However, there are several matters that concern us. We are not in a position to make specific recommendations on the budget but would like to bring to the subcommittee's attention some questions which we believe you should address and take appropriate action on in your own review. We recognize the need for constraints on the total budget but feel that, as in previous years, some fine tuning adjustments by the Congress could result in a better program for the Nation.

In land remote sensing, the fiscal year 1984 budgets of NASA and NOAA appear to be premised on rapid success in handing off to a commercial entity the responsibilities for operation and future provision of civil remote sensing services. However, the administration has not yet come forward with its recommendations on the basis on which bids from prospective contractors will be requested, its proposals for implementing legislation, or its plans for the transition from Government to commercial operations. Until these details have been made known, the adequacy of the NASA and NOAA fiscal year 1984 budget requests for remote sensing cannot be properly assessed.

As the subcommittee is well aware, the commercialization of civil remote sensing raises many controversial and difficult questions that have been the subject of seemingly endless study and discussion for many years. Now, however, leadtimes for maintaining continuity of service after Landsats D and D-prime are running out, if they have not already done so. Our foreign competitors, France and Japan, are continuing to move ahead. It is essential, therefore, that clear decisions be made at this session of Congress either (1) to proceed with a commercialization plan that both protects our national interest and provides a workable framework for attracting effective private participation or (2) to make appropriate adjustments in the 1984 budget of NASA and NOAA to insure that the United States does not forego the benefits of civil remote sensing from space nor abandon our leadership in this field—in which we have invested too much and have had so much technical success—to foreign competitors.

The Space Applications Board has endorsed the movement toward commercialization of at least some parts of the U.S. civil remote sensing enterprise. Last year, for example, we emphasized to this subcommittee that a major market for remotely sensed data could not develop without speedy data handling and assurance of continuity of data. We recommend that the Federal Government should proceed with the transfer of the data reduction and data handling parts of the Landsat program to the private sector as quickly as economically possible, but should defer attempts to transfer to private enterprise the space portion of the Landsat system. We also recommended that the Federal Government conduct a vigorous program of experiments and other technology transfer activities to assist the private sector in realizing the potential benefits of civil remote sensing and also pursue an agressive R&D program on remote sensing technology applicable to civil purposes.

These are still the Board's views, and we hope they will be taken into consideration in the executive and congressional discussions. We would hope that the subcommittee also would give specific attention to assuring that the NASA and NOAA budgets contain adequate provision for maintaining continuity of both operations and R&D in land remote sensing. If a commercialization plan is approved, we feel that contingency provisions should be made in the budget for preserving continuity in the event that negotiations for commercialization fall through or are subject to further delay.

A final point on remote sensing. We note that the 1984 budget proposes eliminating the NASA contribution to AGRISTARS, the

triagency Agriculture-NOAA-NASA program for using Landsat data in surveying and forecasting production of selected crops. The success of this program depends on the collaboration of all three of the agencies, each providing essential special capabilities. We believe that the subcommittee should assure itself that the total funding provided for AGRISTARS in fiscal year 1984, among all the agencies, is sufficient for continued progress in the program and that any change in the funding pattern does not serve to undercut what appears to be an effective interagency working arrangement.

In the meteorological area, Mr. Chairman, the principal concern of the Space Applications Board is that there does appear to be provision in either the NASA or the NOAA budgets for continuing development and test of improved environmental sensors for meteorological satellites. There is also doubt as to whether the NOAA budget provides for adequate continuity in operational civil weather satellites.

The dislocations forced by the 1982 and 1983 budget reductions in NASA and NOAA have had the unfortunate effect of terminating or suspending the excellent partnership arrangement in meteorological satellite activities that had existed between the two agencies for over 15 years. We would hope that the subcommittee would examine this situation carefully and take such action as it finds necessary.

The Board has noted that the discussions of Landsat commercialization were broadened last fall to include the possible commercialization of civil meteorological satellite systems and services. While not wishing to prejudge the merits of whatever proposals the administration may make, the Board seriously questions the advisability of commercializing a service, the weather service, for which the Federal Government itself is the principal customer.

As I have previously indicated, the Space Applications Board is especially pleased that the President's budget has endorsed ACTS, the Advanced Communications Technology Satellite. It has been clear for some time, Mr. Chairman, that the market for space communications is growing and that orbit crowding will almost certainly preclude meeting the demand at the C-band and KU-band frequencies now in use. Meeting future market needs will require new types of satellites operating in the 30/20 gigaHertz band. Our principal foreign competitor, Japan, has also recognized this as the next major area of development in communications satellite and is moving to exploit it.

With advice from the Space Applications Board and with strong congressional support, NASA has now worked out a program approach in which industry will participate actively on a cost-sharing basis. We hope that the subcommittee and the Congress will continue to support the ACTS program as a vital contribution to advancing space technology which can help preserve for the United States a preeminent position in satellite communications.

In the materials processing area, the Board believes that NASA's activities are correctly oriented toward materials science and engineering experiments, as recommended by our Committee on Scientific and Technological Aspects of Materials Processing in Space in 1978. However, we have some concern that the program as present-

ly funded may not make adequate provision for conducting flight experiments using the space shuttle over the next 2 or 3 years, in addition to the ground-based investigations that have been underway and should continue.

Mr. Chairman, your letter to Mr. Plummer asked our views on what NASA should be doing with respect to remote sensing of the oceans. A panel on ocean operations under the Space Applications Board has emphasized—as has the Space Science Board's Committee on Earth Sciences—the great potential, from both the scientific and applications standpoints, of continuous measurement from satellites of key parameters of the ocean, such as surface temperature, currents, wave motion, and so on. The truncated SLASAT experiments and some short duration shuttle experiments have confirmed this promise. It is regrettable that the joint NASA-NOAA-Navy [NOSS] program was terminated in 1981 just as it was about to get underway. The Board believes that the initiation of an oceanic remote sensing satellite should be given high priority for a future new start.

In closing, I would like to stress three points. First, I would like to stress the importance of maintaining a strong level of funding for research and analysis activities in the applications area. While not as glamorous as major identifiable hardware projects, these activities are essential to support the overall space applications program.

Second, it is especially important that NASA's programs include studies and experiments directly involving potential users of space applications. NASA's development of new technologies for space applications must be guided by a realistic practical understanding of the needs and problems of prospective users, and conversely, potential users need to be made aware of the possible ways in which space applications can contribute to their needs and interests.

Finally, I want to stress the Board's strong belief that space applications is a key area of NASA's activities. It plays an essential role in insuring that the Nation actually receives practical civil benefits from our tremendous and continuing investments in space technology. In many areas, such as land remote sensing and communications, it has become clear that Government action, through NASA or other agencies, can make the difference between the realization of benefits or their loss, either to a foreign competitor or altogether. In these areas we must all work together to find ways for the Government—jointly with the private sector, where feasible—to protect the broader national interests and preserve a leadership position for the United States.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Shapley follows:]

(short)

Statement by

Willis H. Shapley
Member, Space Applications Board
National Research Council

before the
Subcommittee on Space Science and Applications
Committee on Science and Technology
U.S. House of Representatives
24 February 1983

Mr. Chairman and members of the Subcommittee, on behalf of the chairman and members of the Space Applications Board, I want to thank you for your invitation to present the views of the Board on the nation's programs directed at the practical uses of space systems by the civil community.

Mr. James Plummer--who is just completing his term as chairman of the Space Applications Board--regrets that he is not able to be here today. He and the Board have asked me to appear here in his stead. My statement has been prepared in collaboration with him and is intended to present the consensus of the Board.

The Space Applications Board was formed by the National Academy of Engineering in 1972, and is now a part of the National Research Council, the operating organization of the National Academies of Science and Engineering. The Board's functions are to help formulate the nation's program for practical applications of space systems, to give independent advice to NASA and other agencies, and to assist in broadening the interest and understanding of industry, universities, government, and the public in practical applications of space technology. The Board's charter and a list of its present members are attached.

Mr. Chairman, as you requested in your letter to Mr. Plummer, I will comment briefly on the FY 1984 budget request for NASA's space applications

activities and address the areas you identified as of concern to the subcommittee.

The Board was briefed at some length on NASA's FY 1984 space applications budget at its last meeting on February 16, 1983. While we have not reviewed the budget in detail, I can give you the Board's reaction to the decisions reflected in the budget.

First, we recognize that the FY 1984 budget is an improvement over the budgets presented to Congress in recent previous years. The complete moratorium on new starts has ended. The administration has now given its approval to the advanced communications satellite technology program which this Subcommittee and the Congress approved last year. There seems to be a green light for moving ahead with UARS--the upper atmosphere research satellite--which has applications as well as scientific significance.

However, there are also several matters that concern us. We are not in a position to make specific recommendations on the budget but would like to bring to your attention some questions which we believe you should address and take appropriate action on in your own review. We recognize the need for constraints on the total budget but feel that, as in previous years, some fine tuning adjustments by the Congress could result in a better program for the nation.

I will comment, in order, on the land remote sensing (Landsat) and meteorological satellite areas, then on communications satellites, materials processing in space, and remote sensing of the oceans. In conclusion I will offer some general observations on the space applications program.

Land Remote Sensing

In land remote sensing, the FY 1984 budgets of NASA and NOAA appear to be premised on rapid success in handing off to a commercial entity the responsi-

bilities for operations and future provision of civil remote sensing services. However, the administration has not yet come forward with its recommendations on the basis on which bids from prospective contractors will be requested, its proposals for implementing legislation, or its plans for the transition from government to commercial operations. Until these submissions have been received the adequacy of the NASA and NOAA FY 1984 budgets for remote sensing cannot be properly assessed.

As the Subcommittee is well aware, the commercialization of civil remote sensing raises many controversial and difficult questions that have been the subject of seemingly endless study and discussion for many years. Now, however, lead-times for maintaining continuity of service after Landsats D and D-prime are running out, if they have not already done so. Our foreign competitors--France and Japan--are continuing to move ahead. It is essential therefore, that clear decisions be made at this session of Congress either (1) to proceed with a commercialization plan that both protects our national interests and provides a workable framework for attracting effective private participation or (2) to make appropriate adjustments in the 1984 budget of NASA and NOAA to ensure that the U.S. does not forego the benefits of civil remote sensing from space nor abandon our leadership in this field--in which we have invested so much and have had so much technical success--to foreign competitors.

The Space Applications Board has been active since its establishment in studying and reviewing the problems of civil land remote sensing. In our reports and testimony we have endorsed the movement toward commercialization of at least some parts of the U.S. civil remote sensing enterprise. Last year, for example, we emphasized to this Subcommittee that a major market for remotely sensed data could not develop without speedy data handling and assurance of continuity of data. We recommended that the federal government

should proceed with the transfer of the data reduction and data handling parts of the Landsat program to the private sector as quickly as economically possible, but should defer attempts to transfer to private enterprise the space portion of the Landsat system. We also recommended that the Federal government conduct a vigorous program of experiments and other technology transfer activities to assist the private sector in realizing the potential benefits of civil remote sensing and also pursue an agressive R&D program on remote sensing technology applicable to civil purposes.

These are still our views, and we hope that they will be taken into consideration in the Executive and Congressional discussions. We have been encouraged to see that the conclusions and recommendations of the Secretary of Commerce's Land Remote Sensing Satellite Advisory Committee, chaired by Michael Halbouty, released last fall, correspond very closely to our views.

In its consideration of the thorny questions relating to commercialization, we would hope that the Subcommittee would give specific attention to assuring that the NASA and NOAA budgets contain adequate provision for maintaining continuity of both operations and R&D in land remote sensing. If a commercialization plan is approved, we feel that contingency provisions should be made in the budget for preserving continuity in the event that negotiations for commercialization fall through or are subject to further delay.

A final point on land remote sensing. We note that the FY 1984 Budget proposes eliminating the NASA contribution to AGRISTARS, the tri-agency (Agriculture, NOAA and NASA) program, for using Landsat data in surveying and forecasting production of selected crops. The success of this program depends on the collaboration of all three of the agencies, each providing essential special capabilities. In previous years each agency, including NASA has provided its share of the funding required, in accordance with an

inter-agency agreement. We believe that the Subcommittee should assure itself that the total funding provided for AGRISTARS in FY 1984 is sufficient for continual progress in the program and that any change in the funding pattern does not serve to undercut what appears to be an effective inter-agency working arrangement.

Meteorological Satellites

In the meteorological area, the principal concern of the Space Applications Board is that there do not appear to be provisions in either the NASA or the NOAA budgets for continual development and test of improved environmental sensors for meteorological satellites. There is also doubt as to whether the NOAA budget provides for adequate continuity in operational civil weather satellites.

The dislocations forced by the FY 1982 and FY 1983 budget reductions in NASA and NOAA have had the unfortunate effect of terminating--or suspending--the excellent partnership arrangement in meterological satellite activities that had existed between the two agencies for over fifteen years. We would hope that the Subcommittee would examine this situation carefully and take such action as it finds necessary.

The Board has noted that the discussions of Landsat commercialization were broadened last fall to include the possible commercialization of civil meterological satellite systems and services. While not wishing to prejudge the merits of whatever proposals the administration may make, the Board seriously questions the advisability of "commercializing" a service for which the federal government itself is the principal customer.

Communications

As I have already indicated, the Space Applications Board is especially pleased that the President's budget has endorsed ACTS, the Advanced Communications Technology Satellite. In a 1977 report "Federal Research and

Development for Satellite Communications", the SAB pointed out the urgent need for NASA to resume work in this area. Other groups, industry representatives and Congress concurred, with the result that NASA undertook a new program of applied research, technical development, and requirements studies directed at future civil needs for increased capacity and new civil applications of satellite communications.

It has been clear for some time, Mr. Chairman, that the market for space communications is growing and that orbit crowding will almost certainly preclude meeting the demand at the C-band and KU band frequencies now in use. Meeting future market needs will require new types of satellites operating in the 30/20 gigaHertz band. Our principal foreign competitor (Japan) has also recognized this as the next major area of development in communications satellites and is moving to exploit it.

NASA, the SAB, industry, Congress and now the administration are in agreement (1) that flight test experiments in the 30/20 gigaHertz range are necessary before private sector compromises can responsibly move ahead with the actual establishment of communication systems at these frequencies and (2) that the private sector alone could not assume the full cost of mounting such a flight test program.

With advice from the SAB and with strong Congressional support, NASA has now worked out a program approach in which industry will participate actively on a cost sharing basis. We understand that formal Requests for Proposals are about to be released by NASA to industry. We hope that the Subcommittee and the Congress will continue to support the ACTS program as a vital contribution to advancing space technology which can help preserve for the U.S. a preeminent position in satellite communications.

Materials Processing

In the materials processing area, the Board believes that NASA's

activities are correctly oriented towards materials science and engineering experiments as recommended by our Committee on Scientific & Technological Aspects of Materials Processing in Space back in 1978. However, we have some concern that the program as presently funded may not make adequate provision for conducting flight experiments using the space shuttle over the next two or three years, in addition to the ground based investigations that have been underway and should continue.

Ocean Remote Sensing

Mr. Chairman, your letter to Mr. Plummer asked our views on what NASA should be doing with respect to remote sensing of the oceans. A panel on ocean operations under the SAB has emphasized--as has the Space Science Board's Committee on Earth Sciences--the great potential, from both the scientific and applications standpoints, of the continuous measurement from satellites of key parameters of the ocean such as surface temperature, currents, wave motion, etc. The truncated SEASAT experiments and some short duration Shuttle experiments have confirmed this promise. It is regretable that the joint NASA-NOAA-Navy "NOSS" program was terminated in 1981 just as it was about to get underway. The Board believes that the initiation of an oceanic remote sensing satellite should be given a high priority for a future new start.

Conclusion

Mr. Chairman, this concludes my prepared comments on the major space applications programs. In closing, I would like to stress three points.

First, I would like to stress the importance of maintaining a strong level of funding for research and analysis in the applications area. While not as "glamorous" as major identifiable hardware projects, these activities are essential to support the overall space applications program.

Second, as the SAB has repeatedly stressed, it is especially important that NASA's programs include studies and experiments directly involving

potential users of space applications. NASA's development of new technologies for space applications must be guided by a realistic practical understanding of the needs and problems of prospective users, and conversely, potential users need to be made aware of the possible ways in which space applications can contribute to their needs and interests.

Finally, I want to stress the Board's strong belief that space applications is a key area of NASA's activities. It plays an essential role in ensuring that the nation actually receives practical civil benefits from our tremendous and continuing invesments in space technology. In many areas, such as land remote sensing and communications, it has become clear that government action, through NASA or other agencies, can make the difference between the realization of benefits or their loss--either to a foreign competitor or altogether. In these areas we must all work together to find ways for the government--jointly with the private sector where feasible--to protect the broader national interests and preserve a leadership position for the United States.

This concludes my statement.

NATIONAL RESEARCH COUNCIL
COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS
2101 Constitution Avenue Washington, D.C. 20418
(202) 334-3272

Charter for the Space Applications Board

The Space Applications Board of the National Research Council will:

Provide to all elements of the Federal Government, including Congress, expert independent advice and broad judgment on the national program for the useful application of space systems in terms of issues, appropriate activities, international relations, and related priorities, emphasizing ways to augment its positive effects on society and diminish or eliminate its negative effects.

Collect and analyze information on the developing needs of concerned segments of the user community and inform them of the state-of-the-art and potentials of space techniques and capabilities.

Stimulate active collaboration among the various components of the governmental and industrial communities whose combined interest and resources will be required to achieve maximum benefit from space applications.

Conduct timely follow-up and impact analyses to assess the effectiveness of recommendations, determine the causes for success or failure, and recommend appropriate remedial actions.

Provide guidance on organization and management problems to the extent necessary to achieve the objectives of the space applications program.

NATIONAL RESEARCH COUNCIL
COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS
2101 Constitution Avenue Washington, D.C. 20418

(202) 334-3272

February 1983

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Mr. VOLKMER. Thank you very much, Mr. Shapley.
Mr. Fthenakis, you can proceed with your testimony at this time.
[A biographical sketch of Mr. Fthenakis follows:]

EMANUEL FTHENAKIS

Emanuel Fthenakis, Senior Vice President, Fairchild Industries, is a native of Greece and a graduate of the Technical University of Athens with degrees in electrical and mechanical engineering. He came to this country in 1952 and earned an M.S.E.E. in communications from Columbia University and did post graduate work at the University of Pennsylvania. Before joining Fairchild Industries in 1971, he worked for Bell Telephone Labs, General Electric Company, Ford Aerospace and Communications, where he was responsible for developing the first United States military communications satellite system, and International Telephone and Telegraph Corporation, where he was president of the Aerospace Division. At Fairchild Industries Mr. Fthenakis has line responsibility for the communications, electronics and space group consisting of several division and/or subsidiaries of Fairchild Industries. He is directly responsible for the operations of the Fairchild Space Company; Fairchild Communications & Electronics Company; American Satellite Company, a communications partnership with Continental Telephone Corporation; and Fairchild's interest in SPACECOM (Space Communications Company), a partnership with Continental Telephone and Western Union.

American Satellite, a domestic satellite common carrier, has developed a nationwide communications network providing commercial service since late 1974; American Satellite has also developed and is operating a nationwide data communications network for the military. Mr. Fthenakis was directly responsible for initiating the activities of American Satellite, developing its organization, services and product capability and directing the legal and regulatory activities.

Mr. Fthenakis is also an adjunct professor at the graduate school of the University of Maryland where he teaches a course on satellite communications. He was elected a fellow of the Institute of Electrical and Electronics Engineers, effective January 1, 1983, "for technical leadership and innovative application of technology in the field of space communications." In 1982 he was named the Electronic and Aerospace Systems Conference's Man of he Year for his managerial and technical accomplishments over the past 25 years including "imaginative pioneering work in digital communications via satellite." He is presently serving as a member of President Reagan's National Security Telecommunications Advisory Committee.

STATEMENT OF EMANUEL FTHENAKIS, SENIOR VICE PRESIDENT, FAIRCHILD INDUSTRIES, GERMANTOWN, MD.

Mr. FTHENAKIS. Mr. Chairman and members of the subcommittee, I will restrict my comments mainly in the area of communications satellites.

The first long-distance communications service by U.S. domestic satellite carriers was initiated in 1974. The three initial carriers were American Satellite Corp., RCA-Americom, and Western Union. They all started almost simultaneously. I am a founder of the American Satellite Corp., which started as a wholly-owned subsidiary of Fairchild Industries. By 1982, there were six domestic satellite carriers in operation, and it is expected that by 1985 three or four more will be in operation.

Almost immediately upon the initiation of satellite service, the U.S. users of our service, including both industry and government, enjoyed an approximate 50-percent reduction in long-distance telephone rates. In addition, other communications services, such as high-speed data transmission and video broadcast, became widely available at affordable rates. As a matter of fact, in the video broadcast area, there are thousands of Earth stations installed every year.

The first generation of communications satellite systems was established during the 1974–81 time period, with the more sophisti-

cated second generation systems starting to replace the old generation in 1981. Construction of these second generation systems is presently in high gear and is scheduled to continue into the 1985–86 timeframe.

The U.S. domestic satellite industry has expended over $2 billion in the 1974–81 period, with an additional $3 billion expenditure anticipated for the establishment of the second generation capability. It is interesting to note that the over $2 billion investment by U.S. industry in the 1974–81 time period did not generate any profit.

The funds expended were divided approximately equally among three major areas: market development, establishment of the communications plant, and R&D. Some examples of the research and development work, which was mostly development are: the upgrade of expendable launch vehicles, frequency reuse technology, satellite delay compensation, echo elimination, specialized switches, terrestrial distribution and Earth station technology, digital video and data compression, and computer-to-computer communications technology.

As we all know, the communications industry and the computer industry are rapidly merging into a common information, generation, and transmission industry. Today, more than 50 percent—actually it was estimated at 60 percent—of the U.S. work force is associated with the information industry, and this percentage is rapidly increasing. The information industry is becoming the major and most vital segment of the U.S. economy. Satellite communications are playing a major role in this important segment of the economy. In addition, it represents one of the few areas in which the United States is still the world's leader.

As I mentioned previously, during the recent years, a period of difficult economic conditions, U.S. industry carried the load in this field with heavy investments as well as heavy losses. Only recently have some of the U.S. satellite carriers started to show a profit. For American Satellite, the first profitable year was 1982, having started operations in 1974. In addition, each of these carriers has committed to additional heavy investment, collectively amounting to several billion dollars, to be expended in the next 3 to 5 years. These investments are absolutely necessary if this industry is to survive and to become viable.

In 1982, the U.S. Government, through NASA, spent $20 million as the front end of a $350 million program designed to enhance the satellite communications capability of the Nation in the 1990's—that is, for the period beyond the one that is supported by heavy industry investments.

In view of the size and importance of this segment of the U.S. economy which includes communications satellite services, the size of the U.S. work force involved in this segment of the economy, the need to maintain our present leadership position in this field against strong competition supported by foreign governments, and the efforts and investment by U.S. industry to establish the field of communications satellite services as a viable economic venture, I think the proposed advanced communications technology satellite [ACTS] program is absolutely the minimum program that the United States ought to undertake. The ACTS program, I personally

think, addresses the important areas that need technological development and flight proof.

However, I believe that it will be difficult for an operating carrier to use the ACTS experimental payload effectively on an operating basis. This is due to the fact that the program will require the early deployment of expensive, specialized ground segment facilities, while the corresponding space segment will have a limited life expectancy and no backup. In the event of failure, a new operational space segment of the same configuration could not be available for several years.

I would also like to point out two additional areas of concern. One, the program must be organized and managed in a way that insures that the technology does not develop in certain isolated pockets of the industry, thus failing to accomplish the stated objective of developing a national capability in this field. Second, this research and development effort must be organized and managed in such a way that it does not become a gift to foreign interests rather than a boost to U.S. efforts in the field. I think that this is a serious threat and that appropriate safeguards must be undertaken.

In summary, I think that it is not only desirable but absolutely essential for the United States to establish a long-range research and development program in the communications satellite field. I believe that although the ACTS program covers certain important areas of technology, it is only a minimum program. I further believe that safeguards must be taken to insure that long-range satisfaction of the stated national objectives are satisfied. Thank you.

[The prepared statement of Mr. Fthenakis follows:]

Cohen

Emanuel Fthenakis
Senior Vice President, Fairchild Industries
Testimony Before the Subcommittee on Space Science and Applications
February 24, 1983

The first long-distance communications service by U.S. domestic satellite carriers was initiated in 1974. The three initial satellite carriers--namely, American Satellite Corporation, RCA-Americom and Western Union--initiated service almost simultaneously. By 1982 there were six domestic satellite carriers operating in the United States, and it is expected that by 1985 three or four more will be in operation.

Almost immediately upon initiation of satellite service, the U.S. users of the service, including both commercial and government customers, enjoyed an approximate 50% reduction in long-distance telephone rates. In addition, other communications services, such as high-speed data transmission and video broadcast, became widely available at very affordable rates.

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The funds expended were divided approximately equally among three major areas: market development, establishment of the communications plant, and R&D. Some examples of the R&D work, which was mostly development, are:

-- Upgrade of expendable launch vehicles

-- Frequency re-use technology

-- Satellite delay compensation

-- Echo elimination

-- Specialized switches

-- Terrestrial distribution and earth station technology

-- Digital video and data compression

-- Computer-to-computer communications technology

As we all know, the communications industry and the computer industry are rapidly merging into a common information, generation and transmission industry. Today more than 50% of the U.S. work force is associated with the information industry, and this percentage is rapidly increasing. The information industry is becoming the major and most vital segment of the U.S. economy. Satellite communications is playing a major role in this important segment of the economy. In addition it represents one of the few areas in which the U.S. is still the world's leader. As I mentioned previously, during the recent years--a period of difficult economic conditions--U.S. industry carried the load in this field with heavy investments as well as heavy losses. Only recently have some of the U.S. satellite carriers started to show a profit. In addition, each of these carriers has committed to additional heavy investment--collectively amounting to several billion dollars--to be expended in the next

three to five years. These investments are absolutely necessary if this industry is to survive and become viable.

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In view of:

1. The size and importance of the segment of the U.S. economy which includes communications satellite services;
2. The size of the U.S. work force involved in this segment of the economy;
3. The need to maintain our present leadership position in this field against strong competition supported by foreign governments;
4. The efforts and investment by U.S. industry to establish the field of communications satellite services as a viable economic venture;

I think the proposed Advanced Communications Technology Satellite (ACTS) program is absolutely the minimum program that the U.S. ought to undertake. The ACTS program, I personally think, addresses the important areas that need technological development and flight proof.

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segment facilities while the corresponding space segment will have a limited life expectancy and no back-up; in the event of failure a new operational space segment of the same configuration could not be available for several years.

I would also like to point out two additional areas of concern:

1. The program must be organized and managed in a way that ensures that the techology does not develop in certain isolated pockets of the industry, thus failing to accomplish the stated objective of developing a national capability in this field;
2. The R&D effort must be organized and managed in such a way that it does not become a gift to foreign interests rather than a boost to U.S. efforts in the field. I think that this is a serious threat and that appropriate safeguards must be undertaken.

In summary, I think that it is not only desirable but absolutely essential for the U.S. to establish a long-range R&D program in the communications satellite field. I believe that, although the ACTS program covers certain important areas of technology, it is only a minimum program. I further believe that safeguards must be taken to ensure the long-range satisfaction of the stated national objectives.

Mr. VOLKMER. Thank you very much, Mr. Fthenakis. We will continue now with the panel. Mr. Yardley, you may proceed.

STATEMENT OF JOHN F. YARDLEY, PRESIDENT, McDONNELL DOUGLAS ASTRONAUTICS CO., ACCOMPANIED BY JAMES ROSE, MANAGER, ELECTROPHORESIS OPERATIONS IN SPACE PROGRAM, McDONNELL DOUGLAS ASTRONAUTICS CO.

Mr. YARDLEY. Thank you, Mr. Chairman. I am pleased to have this opportunity to appear before the subcommittee as a representative from private industry to respond to your request for information on materials processing in space—specifically on McDonnell Douglas' research and planned commercialization involving separation and purification of materials in space. We want to discuss what the process is, how it works, and a little about our 6 years of working with NASA on this sort of program, what the good points are, and what other policy matters should be addressed.

I would like to turn the microphone over to Mr. Jim Rose, who is our manager on the electrophoresis operations in space program, and he will acquaint you with the elements of the program.

Mr. ROSE. Mr. Chairman and members of the subcommittee, the new field of biomedicine or biotechnology may do for the pharmaceutical industry what the chip has done for the computer business. A problem in the development and commercialization of natural or synthesized biological materials is the need for better high-volume processes which also provide extremely high levels of purification. For the past 6 years, the McDonnell Douglas Corp., with its own funds, has been working on a project that could lead to dramatic breakthroughs in the treatment of a number of diseases which could include diabetes, emphysema, dwarfism, thrombosis, and viral infection. May I have the first slide, please. (Figure 1.)

At the heart of this project called EOS, electrophoresis operations in space, is a device which separates materials in solution by subjecting them to an electrical field. In this process, a stream of biological materials is continuously injected into a buffer solution flowing through a thin, rectangular chamber shown on the left of that photograph. When the electrical field is applied, the biological materials pull apart into separate streams. These streams then flow out the top of the chamber and are collected at the right-hand top part of the photograph shown.

We have optimized this process here on the ground. We believe we have significantly advanced the state-of-the-art for preparative biological separations with our process. This advancement in technology is being borne out through our concurrent support of ongoing research at a number of major biological laboratories and universities. Mr. Chairman, Washington University is included in that list.

Our mathematical models and empirical studies show that gravity severely limits the full potential of the continuous flow system as a commercial process. Limitations on sample concentrations, flow volume, and flow stability at increased power levels can be overcome in the absence of gravity allowing the continuous flow process to produce 400 to 800 times more material per hour and at

levels of purity five times greater than achievable here on Earth with the process. Our business planning clearly indicates that the continuous flow electrophoresis system operating in space has the potential of becoming an economically viable method of producing commercial quantities of high value natural biological products to effectively treat a number of diseases. Next slide, please. (Figure 2.)

In late 1978, Ortho Pharmaceutical Corp., a division of Johnson & Johnson, joined us as an active partner to concentrate on those parts of the job unique to the pharmaceutical business. McDonnell Douglas will develop the process, will characterize products with the process, and will develop and conduct the space verification and commercial feasibility flight test programs. Ortho Pharmaceutical will be responsible for product definition and market research, will conduct a product development program—including animal and human clinical testing—and will be responsible for the FDA interface and compliance. In the commercial phase, McDonnell Douglas will develop and operate the commercial space plants. Ortho will package, market, and distribute the products. We believe that by applying the expertise from our two corporations in the appropriate areas, we bring the necessary technical, business, marketing, and management skills to the program to maximize our chances for ultimate success.

We are now flying our experimental electrophoresis device on a series of shuttle flights to fully test its operational characteristics and to verify the advantages of processing in space. The first of these test flights was conducted on the fourth shuttle flight in July 1982. Next slide, please. (Figure 3.)

This shows the three elements that make up the continuous flow electrophoresis test system installed aboard the Columbia prior to the STS-4 flight last June. The objective of our first test flight was to verify that biological materials 125 times more concentrated and 4 times the flow volume of ground-processed preparations would flow and separate with good resolution under zero gravity conditions.

This would establish a minimum of 500 to 1 improvement in process throughput we could expect for the first product we are now developing. Next slide. (Figure 4.)

This is a photograph taken during the flight of the STS-4. T. K. Mattingly is shown in the middeck area. Our equipment, as you can see, is shown behind him against one of the bulkheads. The flight results exceeded our expectation. The process equipment operated flawlessly during the 15 hours of operation, and the six biological separations at varying concentrations exhibited the profiles we expected to see. Purity was not degraded by concentration or flow volume, and throughput improvements of approximately 500 times was clearly demonstrated. If the remaining flight tests go equally well, a production unit could be in Earth orbit by 1987. Next slide. (Figure 5.)

An orderly plan for the development of the EOS program has been laid out with annual milestones defined to measure progress and future commitments. On the first line, a major milestone to note is scheduled in March of 1984 on the fifth middeck flight aboard the STS-12 mission. After a modification to the current middeck unit this fall, two flights scheduled in 1984 will be used to

produce significant quantities of processed materials for use by Ortho in clinical testing. This will be the first time that a large quantity of space-derived material will be used in actual testing in the clinics.

The production prototype unit, shown on the second line of the schedule chart, has 24 times the capacity of the middeck unit and will have two development flights starting in 1985. In addition to verifying the operation of the plant, the processed material will be used to finish the clinical programs, leading to FDA approval, we hope, early in 1987.

Detailed design of this unit started this past August, based on the positive results of the first middeck flight test aboard the STS–4 mission. Next slide, please. (Figure 6.)

The production prototype unit just described is designed to become our first commercial production unit following FDA approval. This unit will be capable of operating in the orbiter bay or as a free-flyer supported in orbit by a yet-to-be-determined dedicated spacecraft or multipurpose space facility.

Since McDonnell Douglas and Ortho are investing significant front-end funds to develop process technology, flight hardware, and new products, the earlier we can commercialize the technology, the faster we can recover our long-term investment and maximize that return. Therefore, we have the incentive to begin commercial operations in space with one product as soon as practicable.

Business planning indicates that an economically viable operation can begin in the sortie mode of operation in the orbiter payload bay as an interim, until an orderly transition to long-duration free flight can be accomplished. If current market predictions remain accurate, we can project the addition of a dozen new plants in space during the nineties to meet patient demands.

Our ability to stay the course and grow beyond this modest beginning may well depend upon the direction NASA takes in the development of long-duration space facilities and services. If we are limited too long to sortie up-and-down operations where the plant is idle the majority of the year, the distinct throughput advantage space offers will be greatly compromised relative to a continuous operating ground facility. A NASA space station facility will allow us to expand production to meet patient demand for the first product and to expand the business to include numerous products which can now be developed with our technology.

In conclusion, from what we know today, we believe the potential for manufacturing new and improved products in space is real. Without long-duration capability, unmanned or manned, market development for any one product is limited. Unmanned long-duration flight support will allow market development for one or more products within the limitations of the space transportation system to logistically support a number of individual plants. A manned long-duration facility can provide the basis for industry growth with greatly improved economics.

Now I am going to turn the podium back to John Yardley, who will discuss some policy questions with you. Thank you.

[Figures 1–6 of Mr. Rose's oral presentation follow:]

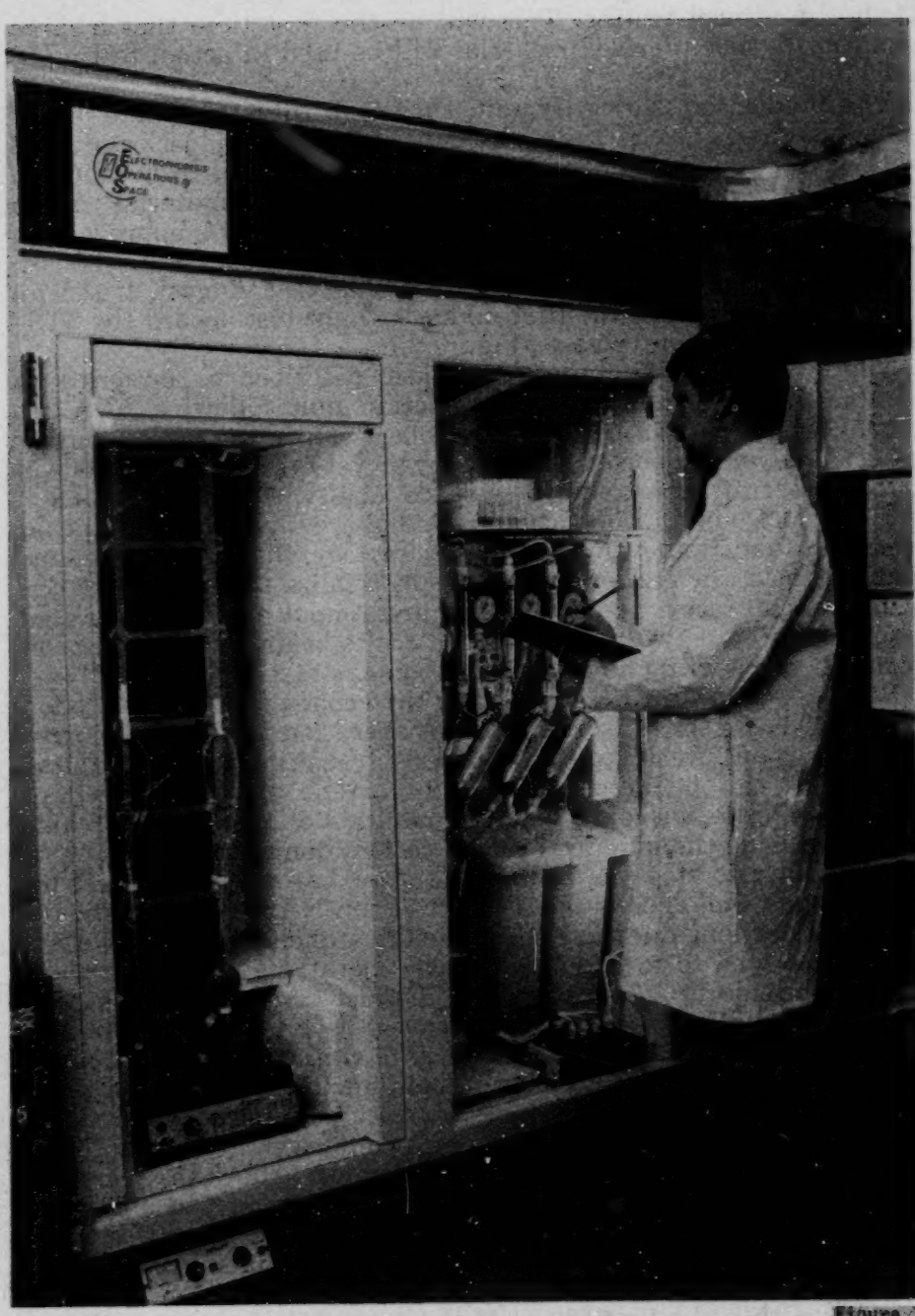

Figure 1

TOP

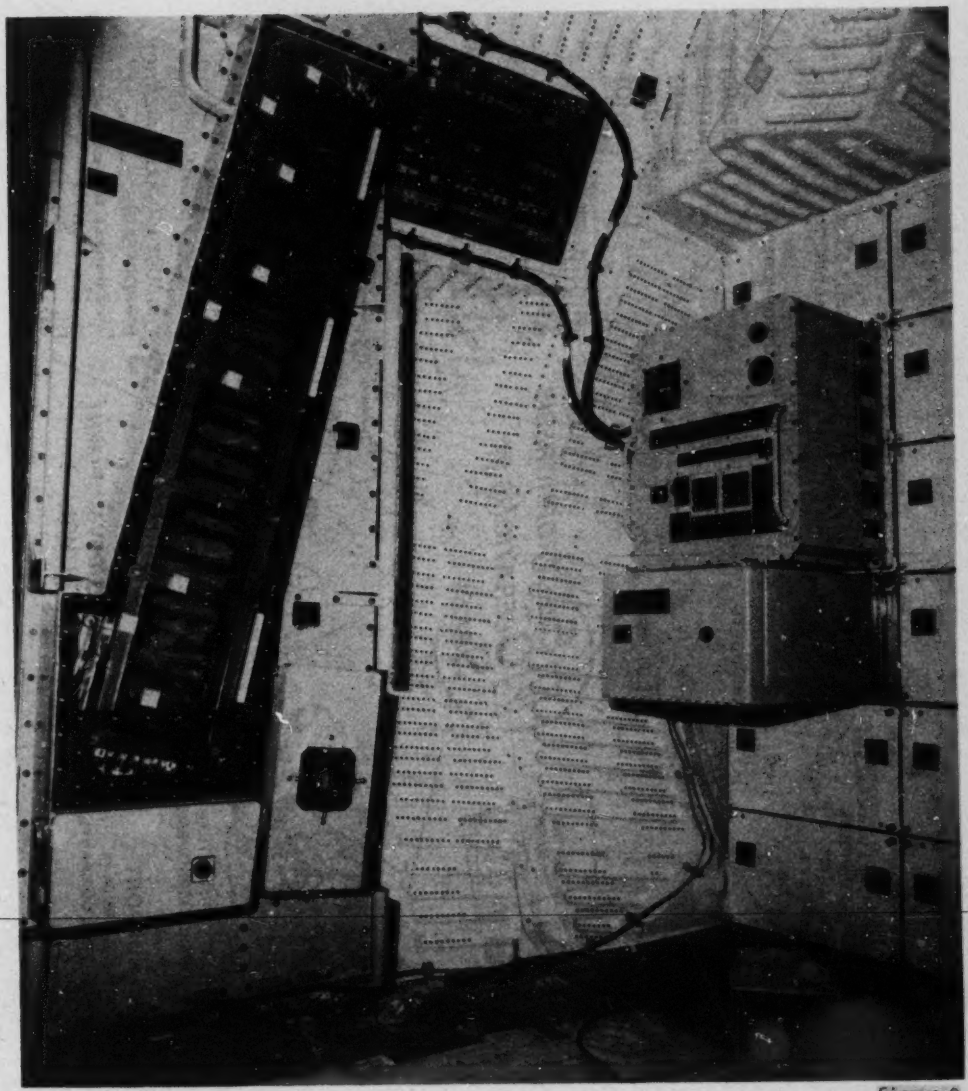

Figure 3

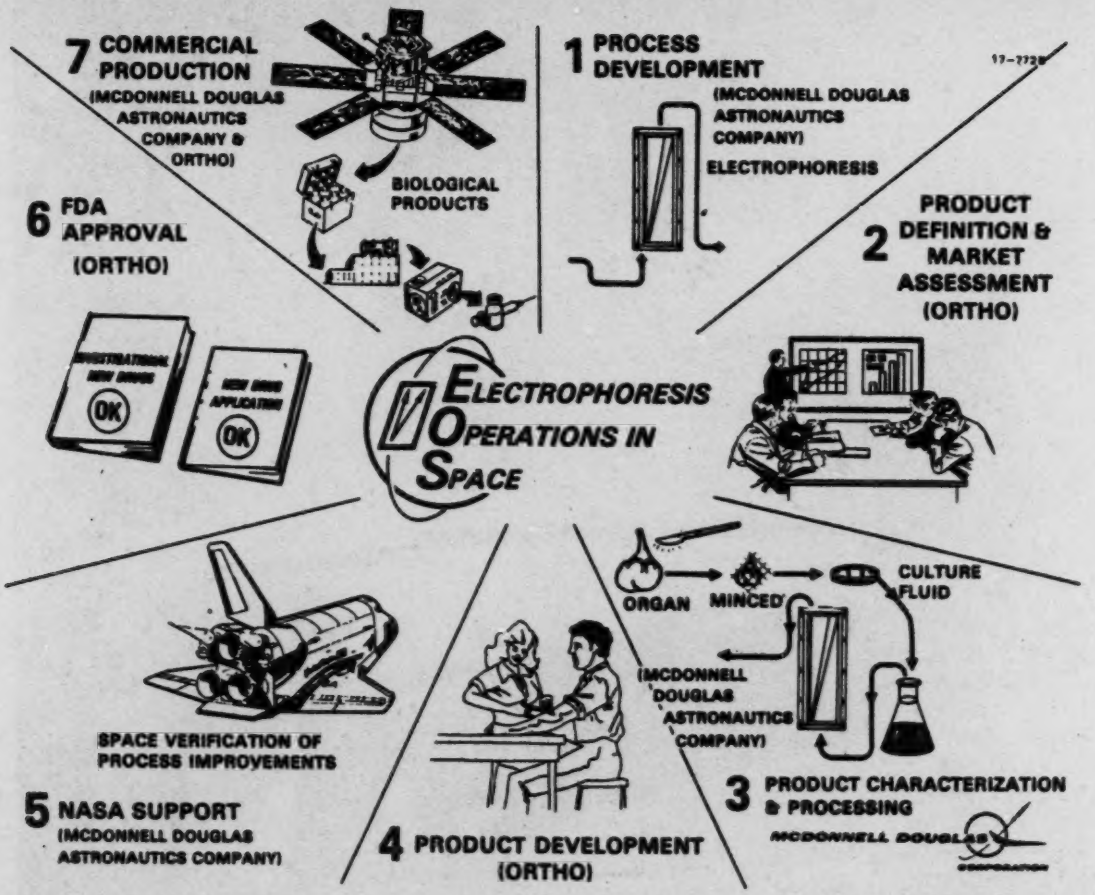
7 COMMERCIAL PRODUCTION
(MCDONNELL DOUGLAS ASTRONAUTICS COMPANY & ORTHO)
BIOLOGICAL PRODUCTS
1 PROCESS DEVELOPMENT
(MCDONNELL DOUGLAS ASTRONAUTICS COMPANY)
ELECTROPHORESIS
2 PRODUCT DEFINITION & MARKET ASSESSMENT (ORTHO)
6 FDA APPROVAL (ORTHO)
OK
OK
ELECTROPHORESIS OPERATIONS IN SPACE
ORGAN
MINCED
CULTURE FLUID
(MCDONNELL DOUGLAS ASTRONAUTICS COMPANY)
3 PRODUCT CHARACTERIZATION & PROCESSING
MCDONNELL DOUGLAS
SPACE VERIFICATION OF PROCESS IMPROVEMENTS
5 NASA SUPPORT
(MCDONNELL DOUGLAS ASTRONAUTICS COMPANY)
4 PRODUCT DEVELOPMENT (ORTHO)

Figure 2

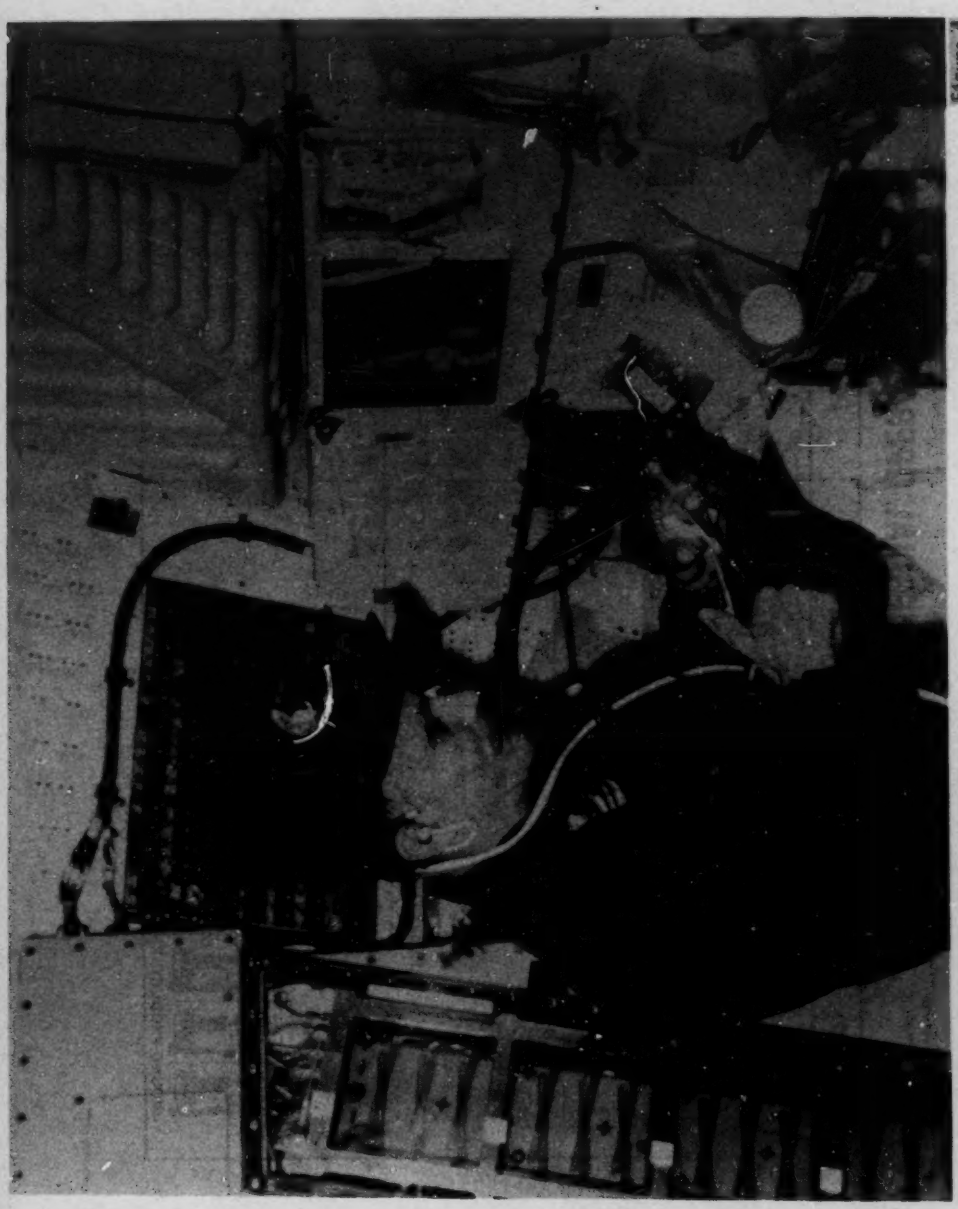

Figure 3

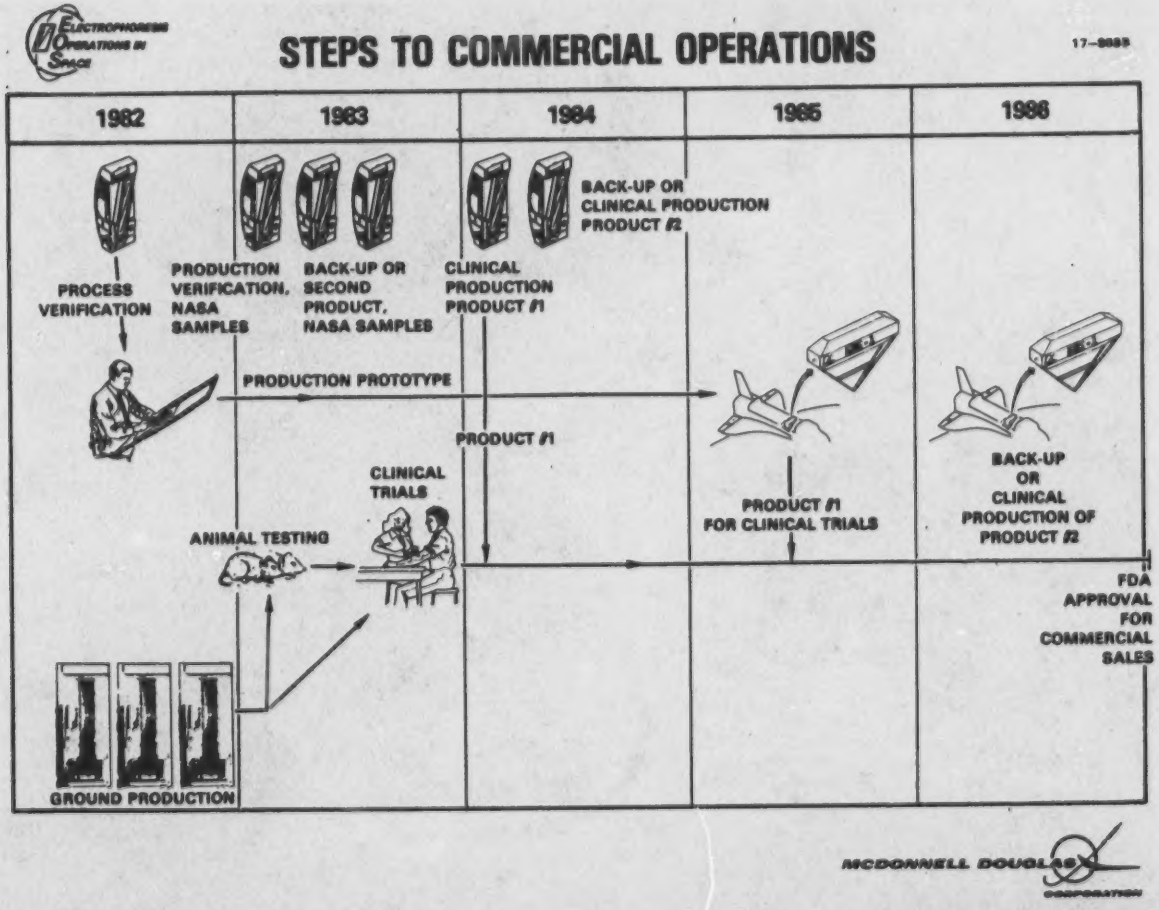
ELECTROPHORESIS OPERATIONS IN SPACE
STEPS TO COMMERCIAL OPERATIONS
17-9989
1982
1983
1984
1985
1986
PROCESS VERIFICATION
PRODUCTION VERIFICATION, NASA SAMPLES
BACK-UP OR SECOND PRODUCT, NASA SAMPLES
CLINICAL PRODUCTION PRODUCT #1
BACK-UP OR CLINICAL PRODUCTION PRODUCT #2
PRODUCTION PROTOTYPE
PRODUCT #1
CLINICAL TRIALS
ANIMAL TESTING
PRODUCT #1 FOR CLINICAL TRIALS
BACK-UP OR CLINICAL PRODUCTION OF PRODUCT #2
FDA APPROVAL FOR COMMERCIAL SALES
GROUND PRODUCTION
MCDONNELL DOUGLAS CORPORATION

Figure 5

Mr. YARDLEY. Mr. Chairman, I would like to just spend a few minutes relating some of our observations after working with NASA for a number of years on this program that Jim has just described. First of all, we are working with them under what we call a joint endeavor agreement. That is an agreement where no money changes hands, but both parties benefit from it.

Basically the way it works is, we provide all the funds to develop the process and build the hardware. NASA provides experimental flight time on the shuttle for us to see if it works sufficiently to develop it and NASA agrees also not to fund a competing effort in our specific field. We retain proprietary rights but give NASA the data to use, so they do not spend appropriated funds doing the same kind of research. Then, of course, we buy shuttle services when it is mature and it is a growing business.

I would like to say, I think this is a very good, enlightened approach that NASA is taking, and I do not have any great recommendations to improve it. I think it is a balanced approach, and I think that if somebody has a good idea, it represents an excellent opportunity to work with NASA to develop it. It hardly costs NASA anything, but it does develop space uses which are in their best interest and in your best interest, which I will comment on later.

So one has to ask, If this is so good why is there not more of it going on? We have been at it 6 years, and there have been other joint endeavors that have come and gone. They do not seem to stick around. In a little introspection, I tried to estimate, at least in my opinion, what some of the additions might be.

One of them, I think, is communications. Most of the companies that are currently in product businesses do not know a thing about space. They fear getting involved with the Federal Government. There is just a big wall there. Aerospace companies like ours are different. We understand space, we understand NASA, we could not survive without being involved with the Federal Government, so we do not have that problem. But we do not know the products. We do not know what the needs are.

One of the problems is how to get communications on a fairly good scale going between these two parts of our industrial sectors that normally do not have any intercourse. It might be worth considering. NASA has technology programs to get technology out, but that is really not what we are talking about here. We need to facilitate communications between industries that might be compatible if a third party, such as NASA or Commerce, got in and fostered better communications. That is something you might want to think about.

Another factor that fits into any businessman's equation when he evaluates whether he is going to put money into something of this sort is the matter of risk and, in particular, risks over which he has no control—what I call uncontrollable risks. One of those is that the administration seems to take a position that commercial space is not their business, it is not their concern. I am led to understand that OMB's current position is that there is no shuttle capacity that will be provided for commercial customers. If there is some excess over what we need for our Government use, then the commercial customers could have it until we need it.

I know a lot about the shuttle and about the needs and about four orbiters and five orbiters, and I can assess and judge that. But a businessman who really doesn't understand what they are saying will think "Gee, I can invest millions and then the Government would shut me off and I would be out in the cold." There is one thing you have to remember about the type of support we are talking about. You cannot use an expendable launch vehicle. Material processing payloads have to be recovered to have a product. So the shuttle is the only vehicle in the world that can do this. That has to be a great concern, particularly to those companies who are not familiar with the whole process.

Another concern to businessmen is that they have a 10- to 15-year leadtime before they really start getting a payoff. You have to make these investment decisions based on what you think it is going to cost, versus what the market will pay. We have a 3-year shuttle pricing policy, and after the first 3 years it doubled. So how is a businessman looking at that track record going to think he is going to have any price stability 10 years from now.

Now, I understand all about shuttle pricing and how difficult it is, but it may be that there should be some consideration given to negotiating long-term commitments, even though they are at a different price, so he knows what he can count on when he makes his decision.

Another thing that Jim mentioned is when you look at the situation, there are no Government facilities—even if you ignore the fact that the shuttle might not be available as a policy matter—there are no free flyers and there are no space stations, and we do not see plans for these moving at a great clip. If they do get going, they could get canceled. So the lack of facilities which you can count on is a certain discouragement to somebody starting in on this kind of business over a 10- to 15-year period.

Obviously we would advocate some of these kinds of facilities, but we know how difficult it is going to be to get them with the present administration policy.

Another thing that I think could be helpful in promoting more industrial participation of this sort, as has been mentioned by others here, is that the applications funding has not been too encouraging in the last few years. If we had a program in application, even a lot more modest than the aeronautical program but of the same sort, where there was a cadre of NASA personnel and funding available to do research in applications, it would give industry some place to start. There are not too many people who are going to invent from basic research all the way up. Most of them are building on some basic research.

Let me give you a couple of reasons why I think some of this would be smart business on the part of the Congress and the Government. The space shuttle is a national system, which this Government plans to sustain for at least 20 years or probably more. It has been often referred to as the DC-3 of the space age, and the DC-3 is still flying after 40 years.

Just as a snapshot of time, in the 1986 to 1988 time period, each total shuttle flight paid for by commercial interests at the going price would reduce NASA's appropriation by $50 million. That is a worthwhile thing to have, if it does not cost a whole lot. Developing

this clientele should reduce the cost to the Government of maintaining the capability.

Of course, there are other benefits. If the type of development we are doing really proves viable—and of course I want to caution everybody, it has a long way to go before it is really proven commercially viable, it could be, as Jim says, that at the end of the nineties there will be 12 different free-flying spacecraft for just this one program. It could be a billion-dollar-a-year business. A few of those coming out of space are going to help the whole economy. These are products that are not available elsewhere. Not only that, but in this particular case, if you did not even make a nickel on them, they have great social benefits.

If one of these processes is successful, one implantation for life will cure diabetes for life. It is that kind of thing. So I urge you to consider some of these things.

Mr. Chairman, that concludes my remarks.

[The prepared statement of Mr. Yardley and Mr. Rose follows:]

(short)

24 February 1983

STATEMENT
OF
JOHN F. YARDLEY
PRESIDENT
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
AND
JAMES ROSE
MANAGER
ELECTROPHORESIS OPERATIONS IN SPACE PROGRAM
MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

BEFORE THE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

Mr. Chairman and Members of the Subcommittee:

I am pleased to have this opportunity to appear before the Subcommittee as a representative from private industry to respond to your request for information on material processing in space; specifically, on the separation and purification of materials, and the likelihood of these processes becoming commercially viable. I would like to take this opportunity to introduce Jim Rose, who manages our Electrophoresis Operations in Space (EOS) Program in St. Louis. Jim is here with me to describe how the electrophoresis device operates, our relationship with the Johnson & Johnson Corporation in ongoing research, and the findings from our testing of this process in the Shuttle. After Jim's statement, I will conclude by addressing that part of your request regarding commercialization of space technologies.

Mr. Chairman and Members of the Subcommittee:

For the past six years, the McDonnell Douglas Corporation, with its own funds, has been working on a project that could lead to dramatic breakthroughs in the treatment of a number of diseases which could include diabetes, emphysema, dwarfism, thrombosis, and viral infection. At the heart of this project, called Electrophoresis Operations in Space (EOS), is a device that will be used in space to obtain certain proteins and cells by separating them from other biological materials. Although many of these proteins and cells are obtainable on earth, the processes used are so limited by gravity that only research quantities are available. In space, however, away from the adverse effects of gravity, it may be possible to obtain these materials in the quantities and purities needed to effectively treat diseases.

McDonnell Douglas's device uses a process called continuous flow electrophoresis, which separates materials in solution by subjecting them to an electrical field. In this process, a stream of biological materials is continuously injected into a buffer solution flowing through a thin, rectangular chamber. When the electrical field is applied, the biological materials pull apart into separate streams. These streams then flow out the top of the chamber and are collected.

McDonnell Douglas has optimized this process here on the ground (Figure 1). We believe we have significantly advanced the state-of-the-art for preparative biological separations with our process. We are currently using this advanced technology to support ongoing research by a number of biological laboratories and universities.

Our mathematical models and empirical studies showed that gravity severely limits the full potential of the continuous flow system as a commercial process. Limitations on sample concentrations, flow volume, and flow stability at increased power levels can be overcome in the absence of gravity allowing the continuous flow process to produce 400 to 800 times more material per hour and at levels of purity five times greater than achievable on earth.

Our business planning clearly indicates that the continuous flow electrophoresis system operating in space has the potential of becoming an economically viable method of producing commercial quantities of high value natural biological products.

In late 1978 Ortho Pharmaceutical Corporation, a division of Johnson & Johnson, joined us as an active partner to concentrate on those parts of the job unique to the pharmaceutical business. McDonnell Douglas will develop the process, will characterize products with the process, and will develop and conduct the space verification and commercial feasibility flight test programs. Ortho Pharmaceutical will be responsible for product definition and market research, will conduct a product development program--including animal and human clinical testing--and will be responsible for the FDA interface and compliance. McDonnell Douglas will develop and operate the commercial space plants, Ortho will package, market, and distribute the products. We believe that by applying the expertise from our two corporations in the appropriate areas we bring the necessary technical, business, and management skills to the program to maximize our chances for success.

McDonnell Douglas is flying its experimental electrophoresis device in the mid-deck of the orbiter in a series of Shuttle flights to fully test its operational characteristics and to verify the advantages of processing in space. The first of these tests was conducted on the fourth Shuttle flight in July 1982 (Figures 2 and 3). These initial test flights should be completed during 1983.

The objective of the first EOS test flight was to verify that biological materials 125 times more concentrated and four times the flow volume of ground-processed preparations would flow and separate with good resolution under zero gravity conditions.

All test objectives on STS-4 were met. Six separations at varying concentrations exhibited the profiles we expected to see. Purity was not degraded by concentration and flow volume. Throughput improvement of approximately 500 times was clearly demonstrated. If the remaining flight tests go equally well, a production unit could be in earth orbit by 1987.

An orderly plan for the development of the EOS Program (Figure 4) has been laid out with annual milestones defined to measure progress and future commitments.

After a major modification to the mid-deck unit, two flights scheduled for 1984 will be used to produce significant quantities of processed material for use by Ortho in clinical testing.

A Production Prototype Unit (24 times the capacity of the mid-deck unit) will have two development flights starting in mid-1985. In addition to verifying the operation of the plant, the processed material will be used to finish the clinical programs leading to FDA approval early in 1987.

The Production Prototype Unit (Figure 5) is designed to become our first commercial production unit following FDA approval. Detailed design started this past August based on the extremely positive results of the first mid-deck flight test aboard STS-4. This unit will be capable of operating as a payload

of opportunity in the sortie mode of operation in the orbiter bay or as a free flyer supported in orbit by a yet-to-be-determined dedicated spacecraft or multipurpose space facility.

Since McDonnell Douglas and Ortho are investing significant front-end funds to develop process technology, flight hardware, and new products, the earlier we can commercialize the technology the faster we can recover our long-term investment and maximize the return; therefore, we have the incentive to begin commercial operations in space as soon as practical.

Business planning indicates that an economically viable operation can begin in the sortie mode of operation as an interim until an orderly transition to long-duration free flight can be accomplished. If current market predictions remain accurate, we can project the addition of a dozen new plants in space during the nineties to meet the demands.

Our ability to stay the course and grow beyond this modest beginning may well depend upon the direction NASA takes in the development of long-duration space facilities and services. If we are limited too long to sortie up-and-down operations where the plant is idle the majority of the year, the distinct throughput advantage space offers will be greatly reduced relative to a continuous operating ground facility. A NASA space station facility will allow us to expand production to meet patient demand for the first product and to expand the business to include numerous products which can now be developed with our technology.

In conclusion, from what we know today, we believe the potential for manufacturing new and improved products in space is real. Without long-duration capability, market development for any one product is limited. Unmanned long-duration flight support will allow market development for one or more products within the limitations of the Space Transportation System to logistically support a number of individual plants. A manned long-duration facility can provide the basis for industry growth with improved economics.

I will now turn the podium back to John Yardley who will discuss some policy questions.

I will now address some policy matters relating to the commercialization of space technologies. Commercialization of space entails great effort by both industry and government. A mechanism that has established an industry/government relationship in this area is the NASA/MDC Joint Endeavor Agreement on the EOS. Under this arrangement, NASA is providing flight support to MDC for precommercial development and MDC is investing front-end money to develop the process technology, flight hardware, and new products. Some basic agreements of this arrangement are:

1. MDC provides private funds to develop, process, and build hardware
2. NASA provides free STS flight time for R&D
3. For the duration of the agreement, NASA agrees not to support development of a competing electrophoresis process
4. MDC pays for flight services after development is complete

This mechanism has proven the ability of private industry and NASA to work well in partnership while allowing both parties to pursue their own long-term objectives successfully.

While a few other joint endeavors have been started in the six years since we began EOS, a number have been abandoned and I don't know of a single other active space processing program of the scope of EOS. In trying to evaluate why more companies are not interested, several points come to mind:

1. Communication - Most companies that are now in businesses with earth-made products that might profit from space processing know very little about space and view the dependency on the Federal Government with great suspicion. Aerospace companies like mine are more knowledgeable about space and how to work with the government, but aren't familiar with the industries that need and market the products. A policy (and funds) that chartered NASA to facilitate communication between such companies could substantially increase participation by the private sector.

2. Uncontrollable Risks - The risks of new endeavors such as EOS are very great because of unproven technology, uncertain markets, and changing national policy over which the private sector has very little influence. I believe it would be of great help if stable national policies could be agreed on between the legislative and executive branches of the Federal Government in certain key areas:

   a. OMB's current position that no Shuttle capacity will be provided for commerical users, and that they can fly only if excess capacity is available is viewed as a very great risk to any private entrepreneur looking at a 10- to 15-year payoff period. Most serious businessmen will not undertake a new space processing program just because of this single policy, even if all other factors looked feasible. Note that communication satellite businesses do have the alternative of Arianne, but space processing requires retrieval and is only able to use the Shuttle.

   b. Even if we get over the above hurdle, the price of Shuttle services over a 10- to 15-year period have a large uncertainty in the mind of a businessman trying to evaluate the viability of the investment. A three-year price stability is sufficient for communication satellites because that covers the time from the investment decision to operating capability. Long-term pricing stability for space processing users should be given serious consideration.

   c. It is felt that many more programs would be started if appropriate NASA facilities would be developed and made available through lease to space processing businesses. A Space Station and some free flyers fall into this category.

3. There is very little government investment in applicable basic research that industry could use as a starting point in space processing. It is recommended that more emphasis be placed on space processing research similar to the programs that NASA sponsors in Aeronautical Research.

Benefits to the Nation - The Space Shuttle is a national system which this government plans to sustain for 20 or more years to come. In the 1986-1988 time period, each total Shuttle flight made for commercial purposes will reduce the required appropriations by around $50M. Thus, it is of real direct benefit to the U.S. Government to develop commercial users. Other benefits accrue due to the overall economic benefits of new technology and products for both domestic and world-wide sales. Some of the products (indeed, the EOS products) will be of great social benefit because they will provide medical solutions to problems which now have unsatisfactory solutions, if any.

Mr. Chairman and Members of the Subcommittee, I wish to thank you for this opportunity to present our work on Space Processing. This concludes my testimony.

Mr. VOLKMER. Thank you. I recognize the gentleman from Florida, Mr. Nelson, for 5 minutes.

Mr. NELSON. Mr. Yardley, how exciting those possibilities are.

Can you help me to understand something? You have been in the development of the shuttle as part of the NASA team, can you help me understand where the very thrust of the shuttle program—that is, to get the cost down per flight so that it could be commercially used—where in the process did that thrust get turned around to the point that you testified to today; that is, to OMB's current position which is that no shuttle capacity will be provided for commercial uses unless there is excess capacity?

Mr. YARDLEY. I really cannot answer that, Congressman Nelson, other than to say I have been told there is a letter written from Mr. Stockman to the Administrator of NASA with those words in it. So it was not on my watch.

Mr. NELSON. If that is the case, that is definitely within the province of this committee. May I request of the chairman that we try to obtain a copy of that letter?

Is it true that when you were still with NASA that was definitely not the policy of NASA?

Mr. YARDLEY. Wait a minute. Let me caution you. I do not believe it is the policy of NASA today, but NASA has to take orders like everybody else. I believe NASA does not want that policy. As a matter of fact, there was a fight with NASA, and they sort of said, "Shut up. Here is our policy." NASA has always supported the commercial part of it and wants to do it. I have been under four different Presidents, and the different administrations have taken different attitudes on this.

By and large, though, this administration is stronger on the view that if it is worth doing commercially, let the commercial companies worry about it. But here you have a situation where there is a shuttle system and it is the only one in the world that can do the kinds of things I am talking about. Nobody can afford their own shuttle system.

Mr. NELSON. Of course not.

Mr. YARDLEY. It is something that the Government either provides or it does not happen.

Mr. NELSON. It is a self-defeating philosophy to say, "Let the commercial guys develop it." If there is no capacity on the shuttle to use it, how can you develop it and apply it?

Mr. YARDLEY. You cannot. Y u have to go out and set up your own shuttle, and that kills ever thing.

Mr. NELSON. That is like waving a red flag in front of me when I see this. It has just recently come to my attention from the bowels of NASA that they are justifying the lack of need for the fifth orbiter because they are cutting back on their flight schedule. They are cutting back on their flight schedule because they do not have enough commercial payloads, which they are losing to the Ariane. If you keep going that way, you keep getting more ingrown and more ingrown, and suddenly you are faced with a program that launches infrequently and its cost per launch is so high no commercial user will ever come and use it.

I have a few more questions, Mr. Fthenakis. You said in your opening paragraph that by 1982 there were six domestic satellite carriers operating. Is Fairchild one of those?

Mr. FTHENAKIS. American Satellite is a subsidiary of Fairchild.

Mr. NELSON. Have you booked any space on the Ariane?

Mr. FTHENAKIS. No.

Mr. NELSON. Of the remaining five carriers, which ones have?

Mr. FTHENAKIS. Several of them have. I cannot enumerate them right now. Southern Pacific has, for example. As a matter of policy, we at American Satellite refuse to book any space on Ariane.

Mr. NELSON. My compliments to you. I think that the message should go forth to some of our friends in these other American satellite carriers that any potential commercialization which could benefit their specific bottom line on their annual corporate statements could be severely jeopardized if we do not get this space transportation system operating in a viable, commercially usable way.

Mr. Chairman, that is my statement. Thank you.

Mr. VOLKMER. Mr. Bateman?

Mr. BATEMAN. Thank you, Mr. Chairman. Like my colleague before me, I am sure all of us found what we listened to a very exciting thing. It is, I think, one of the more remarkable adventures in space that I have heard about. It gives me special pleasure to hear it from someone who has some ancient connections with the First Congressional District of Virginia.

But let me ask, in order to better understand what NASA or, perhaps more particularly, OMB is doing: Do you have any familiarity with how many applications there were for programs on the last space shuttle? Were there commercial applications which were declined for lack of space?

Mr. YARDLEY. I do not believe the situation has arisen yet where there have been any denials. Now, there have been schedule problems. In fact, the shuttle schedule is such that certain commercial communications people have to take the expendable vehicles, the Deltas, this year. But my comments were more for people who planned long range. There is no other system that will do it, and there is no consideration really given unless they have surplus capacity. So if the businessman says, "Are we going to have surplus capacity? Am I going to bet $50 million on it?" That is the kind of thing that is disturbing.

Mr. BATEMAN. The concern is to what extent were applicants for commercial applications discouraged for lack of a predictable program ongoing.

Mr. YARDLEY. I do not think that has been a big problem yet, because the first step in this process is to get some people like us to get an idea that looks good enough, who are willing to put a little money into it. But by the time you start making the big corporate board decisions, those questions have to be dealt with.

Mr. BATEMAN. There obviously is a point where others become as innovative and as willing to take risks as you, with some assurances being made of a continuum in a program in order to justify the initial investments.

I am a little intrigued, and I do not know whether you are the gentleman to shed any light on it, as to what really is the role of OMB in this kind of decisionmaking process, as opposed to it being done by operational agencies of the Government. Obviously, OMB has some constraints in terms of shaping budget recommendations and that sort of thing. If I understand the orthodox role of OMB, it would not be to make operational decisions on the allocation of space on a space shuttle. Rather OMB would decide on the utilization of funds and how much funds for a given number of missions will be available.

Mr. YARDLEY. I think the specific event occurred with relation to whether the fifth orbiter would be funded or not. That was the letter in question. Without commercial uses, it cannot be justified. As a practical matter, I would just give you some observations from having operated inside NASA for 7 years. OMB is 99 percent of the communication that the agency has with the administration. Now, if the administrator feels very strongly about something, he can meet with the President, but OMB will have been there first and he has an uphill fight.

Mr. BATEMAN. I was going to ask if any of you other gentlemen had any comments you would like to offer along these lines.

Mr. FTHENAKIS. Yes, I do. The question was asked before if we reserved any time on Ariane. We had to go through a major soul searching process on what to do when we were committing over $300 million for the next communications satellite system we are deploying for American Satellite. I will say that the unavailability of the shuttle was a major concern. In effect, we had to delay the date on which we procured the satellites because the shuttle was not available. I am talking of the 1985 period now. If we go today and ask for a reservation, it will be in 1985. In addition, we have to pay out additional money to back up that position through an expendable vehicle, the Delta. I can tell you that as the chairman of the board of American Satellite, I went through a lot of convincing that we had to spend a lot of extra money on the Delta to avoid going to the Ariane. Others have not felt the same pinch that we have; there is no question in my mind.

I would also like to mention to you that Ariane is booking flights, but the actual vehicle they are talking about does not exist. It is an imaginary vehicle, yet to be built.

Mr. BATEMAN. What are the connotations of this, in terms of going forward with, and on an expedited basis, the space lab or

space station? What dimensions does that afford us than, as some would see it, a more enlightened shuttle program would offer?

Mr. FTHENAKIS. I cannot answer that question. I do not know if the others can.

Mr. YARDLEY. As I understood the question, you mentioned both space lab and space station. Space lab is a vehicle that flies inside the shuttle and is equipped to run experiments. For a long time, Jim and his people were working on using that vehicle in this program that we just talked about. It would be a lot more difficult than what we are doing. But the space station would have some real advantages, not the least of which is, if the country committed to a space station, then you know that they are going to commit shuttle flights to go up there every few months, and then you would have this continuity that will solve some of these previous problems that I mentioned. Plus, it will give us easy access to do R&D. Right now we are doing R&D on the shuttle mid-deck. We can get at it and change samples and conduct the necessary research. You cannot do that in an unmanned free flyer, which we can use for production. But even in the unmanned free flyer, you have to go to each one, it has to be a special activity, and there is no pricing policy established for going to pick something up and bringing it home. That can be quite a problem if you do not have someone else going at the same time, the same day, and so on. Otherwise, you might have to buy a whole shuttle flight to get your product back. The space station would consolidate all this. You could get regular schedules, and there would be all sorts of other shuttle users going up and coming back down. It would fit in well.

Mr. BATEMAN. Thank you, Mr. Yardley.

Mr. VOLKMER. The gentleman from California?

Mr. BROWN. Dealing with the subject of a space station we were just discussing, it is my general understanding from reading the press that NASA would attach a high priority to going ahead with the space station but that does not yet have the approval of OMB and the administration. They are authorized to continue with studies of the space station. Is that general understanding correct?

Mr. YARDLEY. That is correct, except that the funding was cut to a point where they are going to bring all the studies in-house this year.

Mr. BROWN. If it were the opinion of the Congress, and of course starting in this committee, that we ought to speed up the planning and the time of initiating a space station, could you give me an indication of the order of magnitude of the budgetary impact in 1984? In other words, what would we need to signal the administration that we would like to accelerate this process, not necessarily override the decision of the administration but to nudge them along a little bit faster in this direction?

Mr. YARDLEY. I am told that they requested $64 million from OMB, and they got $15 million.

Perhaps Mr. Shapley has more accurate information.

Mr. SHAPLEY. No, I have not heard any specific figures, but I think what is needed is a much broader base of studies and investigations, so that when we decide what to do we make the right decision based on lots of good information, rather than without it.

ELECTROPHORESIS OPERATIONS IN SPACE

PRODUCTION PROTOTYPE IN SHUTTLE PAYLOAD BAY

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- AUTOMATED PRODUCTION PROTOTYPE UNIT: 3-5 FT LONG X 14 FT WIDE, 5,000 LBS
- CHECK OUT CONTINUOUS OPERATION FOR FIVE DAYS DURING SEVEN DAY SORTIE
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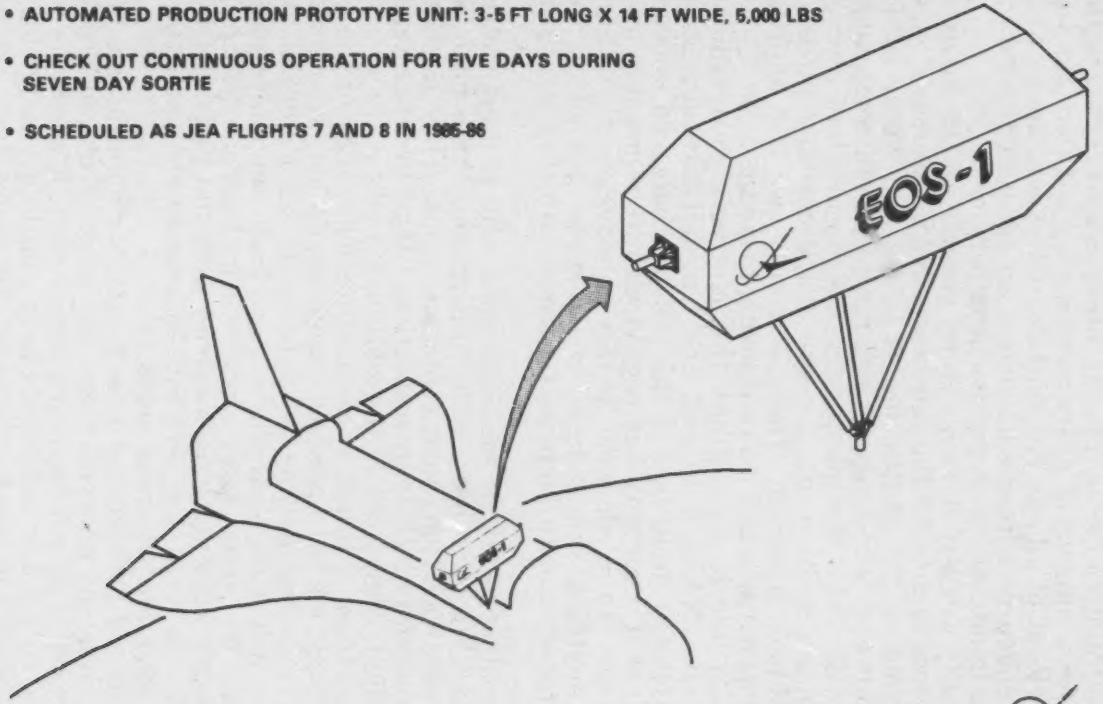

MCDONNELL DOUGLAS CORPORATION

Figure 6

Mr. BROWN. And that would involve the funds to do some outside contracting, not just in-house; is that correct? The industry would have to be involved in it?

Mr. SHAPLEY. I would certainly think so.

Mr. LUJAN. Would the gentleman yield? I would be glad to give some time when I get some.

Mr. BROWN. Certainly.

Mr. LUJAN. But I think in this particular instance—it is my understanding—the cut in funding and the bringing of those studies in-house was by design, not just because of the funding reduction, in order to build up that capability within NASA. They were having trouble with people that felt they were not getting any hands-on experience, and were becoming just paper shufflers managing contracts. That is the reason it was brought in-house and the whole cut was by design, rather than saying "OMB did not give us the money, so we were not able to go out for any contracts." I thank the gentleman.

Mr. BROWN. We will undoubtedly discuss this further. I just wanted to get an order of magnitude. We are talking about somewhere between $15 and $65 million, as the range of difference here. So that if we were to add another $25 million, in speculation, that would at least signal a desire to speed up this process a little bit. I did not want to belabor that.

Frankly, I am more interested in some of the other things that are developing. Let me bring up the Landsat situation. I noted, I think in this morning's paper, that Landsat 4 has suffered a failure and is unable to send data back. Did anybody read that article?

Mr. SHAPLEY. Mr. Brown, I saw that also and made some inquiries. What has happened is that one of the transmitters to send the thematic mapper data back down to the ground has failed, and they have been unable to start it up again. This is not a permanent disaster, because when the TDRSS tracking and data relay satellites go up, the Landsat satellite can pass its data on to them through a different transmitter on a different frequency. It does mean there will be a period of 2, 4, or 6 months in which reception of thematic mapper data will be suspended.

Mr. BROWN. Mr. Chairman, could I ask if the staff could get an up-to-date report from NASA with regard to this reported failure because it has a bearing on our considerations this year. The interrupted data flow from Landsat-D was one of the factors which had concerned many people such as international users of the data and so forth. It has a bearing on our thinking, and it should have a bearing on the administration's thinking, about the commercialization. If we are still faced with testing the equipment, then we are not ready to fully commercialize this operation. That is dictum on my part, but would you comment on that. Are we ready to commercialize the Landsat program at this stage?

Mr. SHAPLEY. I will take a try at that. I think the Landsat satellites probably are at the state of development where, if other factors were favorable, they could proceed with the commercialization of it. This failure, as I understand it, is of a type that could go wrong anywhere. This is in a relatively simple component that has always worked before. It is a simple transmitter that has, for some reason or the other, broken down.

Of course they have not finished their investigation of this yet—but I do not think that this failure, in and of itself, reflects on the maturity of the systems for commercialization. This is the very first flight with a thematic mapper, and it has shown so far that it can do what it is supposed to do. But we have had only almost a half a year experience with it. So as things mature, perhaps other problems may develop. But up to now, all the reports I have had are that the system is basically an unqualified success.

Mr. BROWN. Mr. Shapley, you have commented in your statement on behalf of the Space Applications Board, the importance of having users gain experience with the product of Landsat. Have you had an opportunity to review the product coming back from Landsat-4? I saw some startling pictures the other night.

Mr. SHAPLEY. At the Board, we have had several briefings and have been exposed to the results and reports relating to them. We have not made any independent indepth investigation of them. When the specifications were first drawn, it seemed quite clear, based on the aircraft experiments at that time, that if you could get this kind of data back from space, there were ways you could use it in crop surveys, geological, exploration, and other applications. What they have now shown is that you can get the data from space, and apparently some of it is even better than expected. So now with just one scene per day, which is the present capacity, we are at the stage where these materials have to be used and people can demonstrate to themselves in the real world that they can do what they thought they could.

Mr. BROWN. You are saying that the Space Applications Board really has not had a chance to look in depth at the potential range of marketability of the product yet?

Mr. SHAPLEY. That is correct.

Mr. BROWN. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you, Mr. Brown.

The gentleman from New Mexico?

Mr. LUJAN. Thank you, Mr. Chairman. A couple of things. You criticize OMB for saying if the Government does not need all the space on the shuttle, then industry can use it. How else can they do it? If it is a Government program, how else could OMB do it? Should they put off some of their own experiments to accommodate private industry?

Mr. YARDLEY. The idea would be to provide a national system for the Nation. The Government is only one part of the Nation. Sometimes OMB does not recognize that, but that is the fact. If the Nation wants to stagnate economically, you do not do those things, but this is the type of policy making that nobody but the Government can do.

Mr. LUJAN. Can we have more flights?

Mr. YARDLEY. We can have a policy which says that we will provide the capacity that the country needs. That is all. I do not say you ought to buy a fifth orbiter today. But when you have a policy that says, "Do whatever you want but someday if we get full, too bad," then people are not going to make long-term investments.

Mr. LUJAN. I am not quite sure how you do that. We have two orbiters right now. How can you make a policy that we are going to

take care of everybody? I would like to know, because I think that is good.

Mr. YARDLEY. You have four orbiters agreed to by the administration and they have been funded by the Congress.

Mr. LUJAN. But we only have two. How do we tell everybody that anybody who wants to send up an experiment can do it. There are limitations of space.

Mr. YARDLEY. There have been limitations of space in the past, primarily due to schedule slips for the shuttle, that were beyond NASA's control. NASA did make available alternate vehicles, and anyone who wanted to could also go to Ariane. Right now, if you go to NASA, they have space available in 1985 because a lot of people did go to Ariane. My concern is in the long-term policy of not including the industrial community in the planning.

Mr. LUJAN. Let me get on to this transition that Mr. Brown was talking about. One of your statements, Mr. Shapley, was that we have a system by which we eventually get there. How would we do that? You have talked about data processing for whatever data we get. Would we put those out to contract first and do it slowly?

Mr. SHAPLEY. Many different ways of doing it have been discussed. What we are all eagerly awaiting is to see how the people in the administration who really have the responsibility and have studied this all the way down to the bottomline, have come out. One approach would be to place out for bid a contract for the operation of the data reception and data handling system—have this run by a commercial concern, who would then sell the products to whomever the prospective users are. They could sell them to the Federal Government, to the State governments, to private concerns, to geological exploration concerns, and to anyone else. In effect, this would commercialize the operation that is now done by the Government out at Goddard and out at Sioux Falls, at the EROS data center.

Mr. LUJAN. Are you talking about weather information?

Mr. SHAPLEY. No; at this point I was referring just to the Landsat operation. The operation of the system, the processing, and sale and marketing of the data could be taken over by a private concern.

Mr. LUJAN. Do you think a company could make some money doing that?

Mr. SHAPLEY. I think so, yes. One of the reasons why this seems to be preferable to commercializing the whole thing—satellites and everything else—is that in the latter case the company would have to put up a tremendous front-end investment. The company would have to put up I do not know how many hundred million to start producing whatever the replacement for the Landsat-D double-prime satellite would be. The leadtime has run out. They would have to start with a tremendous investment.

In the arrangement that I was suggesting, the Government has made the investment. The assets could be leased to the contractor or some other arrangement worked out. The original capital requirements would not be as great, and in the view of many could reasonably be expected to be recovered by the charges that would be made for the sales of the product.

Mr. LUJAN. Would you think that at this point a company would pay NASA or would be paid by NASA for receiving and translating and selling all the data? Which way would it go? Suppose it were put out to bid? That is two ways: one you pay and one you receive. We have a buyer here.

Mr. SHAPLEY. I think the concept would be that the contractor would, in effect, bid for the franchise to operate this part of the system.

He would assume various obligations, including to conduct himself in accordance with our international commitments and things like that. But I am not sure there would be a major problem of under what conditions he would operate the equipment. If it is leased to him, he would be paying the Government. The arrangement might be that it would be provided free of charge for some number of years and then a different arrangement would come into being. These are the kinds of details that would have to be worked out. But it seems to us that there would be ways of doing it.

Mr. LUJAN. Mr. Fthenakis?

Mr. FTHENAKIS. We actually examined this in our company. We examined the possibility of doing that business in some detail, and we came to the conclusion that it is probably a viable business for industry to do. We have under serious consideration the possibility of proposing that to the Government. We have a certain model which we will propose, but we are not ready to discuss the model. We do think it is a viable business.

There is a problem with the data, because there are substantial amounts of data coming down, and each user has a different piece of data he needs. It is not easy to take it out of this big stream so that each can select his own part. The first thing that the industry has to do, whoever undertakes the task, is to collect all the data, separate it, and disseminate to the right user the right piece of data. That is a major task.

Mr. LUJAN. Maybe they can use this electropheresis system they are talking about, separating out all that data.

Mr. FTHENAKIS. Unfortunately, there is not a way to do that, but I think it is a viable commercial venture, and a company like ours would be willing to step up and make the investment to do it.

By the way, in that program our company, Fairchild, has announced that they are willing to finance, not a big space station, but a small type of spacecraft to stay in orbit and, in fact, provide a limited but adequate service for this kind of an experiment. We are being committed to putting several hundred millions of dollars to do that. We are in the process of negotiating an agreement as to how to do it.

Mr. LUJAN. Let me ask you a question it really would not serve your interests to answer, but how do we keep a Fairchild from monopolizing this whole thing? Who but a large company can go in and try to make these arrangements with NASA to take over the entire receiving and other operations?

Mr. FTHENAKIS. Let me answer it this way. All of those ventures, like the communications venture that American Satellite or Fairchild started are intrinsically capital-intensive ventures. So not everyone can do it; only a company that can satisfy certain criteria in

the marketplace where we are working today. Number one, it has to have access to capital, and it must prove to the financial community that it can prudently use that capital to insure a return back to the people who invested the capital. Any company that has that capability will be able to do that.

Mr. LUJAN. So there is no way to have any mom-and-pop operations up there?

Mr. FTHENAKIS. I do not think you can have a mom-and-pop operation, although moms and pops started that thing. There are ways by which, if you have the right credibility and the right approach, you can do it. We have an example how Fairchild started American Satellite. We took an entirely different approach from IBM or AT&T. We almost had a mom-and-pop approach, and we are now a several hundred million dollar company. The truth is that when you have a capital-intensive business, you have to have the ability to obtain that capital.

Mr. LUJAN. I have one final thing. You are talking about being able to do your experiments in a free floating, unmanned space station. How would you go up and get your medicine, to milk the satellite.

Mr. YARDLEY. That is the shuttle's job. You cannot do it without a shuttle. You would have to go back to the way we did Mercury and Gemini 20 years ago. You make a heat-protected reentry vehicle, you reenter, and you get the Navy out in the ocean, and that puts you out of business right there. So without shuttle's unique capability of retrieval, space material processing business cannot exist.

Now, one thing about electrophoresis, it does not matter which orbit it is in. It will operate in anybody's orbit. You pick a very common orbit. The most common orbit that we are using today is the 28 degrees inclination—due east—for commercial satellites. You put your satellite in orbit, maybe it is Mr. Fthenakis' free flyer, which incidentally, we are working with him on, as a possibility for the electrophoresis carrier. So when they put out some communications satellites on the same flight, we can milk the electrophoresis device and put some fresh juice in it.

Mr. LUJAN. It sounds awfully complicated.

Mr. YARDLEY. Well, if you have diabetes, it is not so bad.

Mr. LUJAN. That is right. Thank you.

Mr. VOLKMER. Mr. Dymally?

Mr. DYMALLY. Thank you, Mr. Chairman.

Mr. Yardley, you made reference to a letter from OMB. Does the letter suggest that the private sector ought to pay for the commercial flights?

Mr. YARDLEY. I have not actually seen the letter.

Mr. DYMALLY. Allegedly.

Mr. YARDLEY. It is hearsay, you might say. I do not know whether it says that or not. I believe it is silent on what the commercial interests do. It may be that OMB is thinking that they could commercialize launch vehicles. Of course, there are a lot of people talking about that, and that would be a possibility for those those payloads like communications satellites that just needed a launch. But for something that we are talking about, materials processing,

bringing useful high-value products back to Earth, that will not work.

Mr. DYMALLY. Are you suggesting then that in this instance we do need some Federal help?

Mr. YARDLEY. I think that the U.S. Government in total needs to take a policy position, as opposed to OMB interpreting a general policy of the administration in a specific way like this. The policy issue is, Do we want to capitalize on our capability that we, the taxpayers, have invested—about $15 billion—in a manner that brings back economic benefits and other social benefits by letting people use it commercially or by providing services at cost—and they will pay for them—or do we want to forgo that and not have those benefits? That is the policy question that I do not think OMB ought to have the last say on. I think the committee members and the rest of Congress have a say on it.

Mr. DYMALLY. I can anticipate your reply in the affirmative. My question is that the Congress ought to begin to formulate such a policy, in the absence of any executive policy in this matter.

The next question is, I find it rather interesting that the private sector here—and I think at least three of you are from the private sector. I do not know if Mr. Shapley is from the private sector—I believe you have seen that you cannot let the private sector do it all, as this administration is wont to do. They are saying that the private sector can take care of jobs, the private sector can take care of charity. There are times when the Government is needed.

Mr. YARDLEY. Absolutely. If you are talking about using the shuttle, there is nobody, not even in any other country I think, that could sustain that sort of a system. To have a policy that limits the country's benefits from that—and I want to emphasize, we are not talking about subsidy or charity here. We are talking about being a part of the system and being willing to pay for our part. But we cannot generate the system. We only use a small piece of it.

Mr. SHAPLEY. There was a comment in my statement that there are some relatively small and not necessarily very costly things that the Government can do to facilitate and insure that private enterprise does actually do what it is expected to. The Administration's policy on matters like this has gone through some evolution in the last 2 or 3 years. From almost the very beginning, the administration agreed with its predecessor administrations that the funding of basic research was an appropriate role for the Government. Congressman Brown has had a great deal to do with that over many years.

That has been rationalized, if you please, by the fact that it is long-term in nature, and it is very difficult or impossible for any one company, if it does basic research, to capture the benefits and make a profit. Now, during this past year, there was a significant switch on aeronautics. In the earlier years of this administration they applied a very strict standard—the sort that Mr. Yardley has referred to—saying that this was not the Government's business and that private enterprise should do its own aeronautical research.

In the policy which was enunciated last fall, the administration now realizes, and has accepted and has made it its policy, that it is

in the national interest for the Government to support advanced technology development in the aeronautical field, for exactly the same reasons: that it is long-range in nature, that it is unlikely that any single company can capture the benefits of it. I guess the hope of some of us at the Space Applications Board is that this same mellowing of position, if you please, or evolution of thought, will gradually be applied to some of the other areas where it seems to us the same criteria would apply.

Mr. DYMALLY. It is very reassuring to hear someone say that Government is needed still. After all I read from this administration, I begin to think we do not need any Government.

Mr. Yardley, last week, prior to reapportionment, I had the privilege of representing the Douglas Torrance plant. Last week I was induced to go into a very obscure area called the Misquito Region. You have been reading a lot about it. The only way to get in there is to fly. There is no road, no trains. What do you think we flew on? A good old DC-3. It did my heart good. As rugged and as sturdy as ever. Thank you very much, Mr. Chairman.

Mr. VOLKMER. Mr. Walker?

Mr. WALKER. Thank you, Mr. Chairman.

As a new member of the subcommittee, I have been doing some background reading on some of these things. I find some theorists who are suggesting that if we put together the proper kind of program, even now, we could generate from outer space a space-based economy of nearly a trillion dollars by the turn of the century. Are there any of you, as practical businessmen, who believe that we could do that well that soon, or can you give me some idea as to how soon we might be able to generate a trillion-dollar economy from outer space?

Mr. FTHENAKIS. There is no question in my mind that one segment of the space business—the communications area—can generate substantial revenues. I cannot tell you if it comes close to a trillion, but I am sure it comes to several billion. I would guess that the communications segment will really be the one to lead the whole thing. I would say it would be several billion.

What year did you mention?

Mr. WALKER. The turn of the century is what they say. If we went to almost an Apollo kind of effort and went to space stations and all this kind of thing, the potential is there for a trillion-dollar economy.

Mr. FTHENAKIS. I would say that on communications and information alone, it will be in the hundreds of billions.

Mr. WALKER. I was interested, Mr. Fthenakis, in your comment about the fact that your company is willing to go into a small space station kind of production and are dealing with NASA on that. Is this the kind of development where there would be potential? Have you looked at the potential of then tying together a series of small space stations that would already be developed by your company and making a large space station out of it?

Mr. FTHENAKIS. No, we have not looked into that. We have looked at the self-contained small space station. I think when you start talking about a fairly major one you are considering a different order of magnitude. Are we talking about a shuttle that the Government can do but industry cannot do. What we are saying is,

we are willing to use our expertise and money for a project that is reasonable for an industry like ours.

Mr. WALKER. What I am suggesting is whether or not there is some piggyback kind of arrangement that would even cut the cost for Government that might be developed out of this, if you were putting the kind of money that you would have to put in to developing a small station. I am wondering if there is some way that it can be piggybacked into an arrangement that would result in Government getting a larger space station as a follow-on.

Mr. FTHENAKIS. Thinking as I am sitting here, it probably is feasible.

Mr. WALKER. In reference to commercial space stations, is there, in your mind, an applications activity that would take place on a space station, that would justify the kind of investment needed to put such a station into orbit?

Mr. YARDLEY. I don't think commercial alone can justify it. It is kind of interesting that a couple of ex-NASA people were in my office several days ago exploring the possibility of a commercial space station, Bob Gilruth and Max Faget, very senior manned space people for years and now retired.

I personally don't think it's a viable thing. It will be viable probably by the turn of the century, but it gets into a chicken-egg proposition. Nobody is willing to make the commitment now because they've got to do lots of research in the facility to build the business to support a commercial space station.

Mr. WALKER. Your testimony would be that we would have to have Government efforts aboard a station to justify the investment. You don't see it as being strictly a commercial kind of thing.

Mr. YARDLEY. Their plan in investigating the viability of this would be to see if they could get some Government commitments for a certain percentage of its use.

Mr. WALKER. When? We talked about the turn of the century a moment ago. When do you think commercial activity alone might justify a fairly sizeable space station?

Mr. YARDLEY. Well, I would say around the turn of the century if there is a space station prior to that. But if you don't do anything then it's going to be a lot slower development phase.

Mr. ROSE. We have taken a look in just the pharmaceutical aspects and have estimated that in a permanent manned environment, we could probably develop 15 new products over a 10-year time period, and bring them to the market place, as compared to 3 using the sortie piggyback mode of operation. So the number of products that can be produced and brought to the public is going to be tremendously enhanced. I think that is what John is intimating. Once you get these products into flow they in turn would ultimately justify a space station, but it is a chicken and egg thing.

You need a facility to speed up the development of this industry—to achieve total growth of this industry. Pharmaceuticals can be a major industry using the space environment. Right now we are taking it one step at a time, and we are going to start a business. This way, what this whole business becomes for this country, really depends on a permanent manned-type facility being available.

Mr. WALKER. Are you, as businessmen, satisfied with the commercial marketing expertise that's at NASA right now? Hasn't NASA become essentially a marketeer at the present time where we have them selling all kinds of products? My initial reaction is that this is not what they were set up to do and I'm raising a question of you who are hardnosed businessmen who have to compete out there. Whether or not that is one of the problems that we face—that they really aren't the kind of commercial marketeers that we should have selling not only the product but the concept as well? The kinds of vision that some of you have talked about here?

Mr. FTHENAKIS. As of this moment we're not at the doors of NASA. They're not offering things for us.

Mr. WALKER. They aren't around selling?

Mr. FTHENAKIS. They aren't around selling.

Mr. WALKER. But should they be?

Mr. FTHENAKIS. Well, that's a different question as to what is the purpose of NASA.

Mr. YARDLEY. NASA is out selling shuttle flights to a commercial community. We work with them because we also have a commercial space product called "Payload Assist Module" which is an upper stage to boost communications satellites to geosynchronous orbit. They've been to Australia, Colombia, and Mexico, so they are working hard at it. They have some limitations. They have good people working the problem, but not much previous marketing experience. But being a Government organization does limit their ability to market. I'm on a NASA chartered committee now that is studying a number of problems preparatory to advising NASA. The consensus of that committee right now is that NASA should lead the marketing, but probably they need to get a contractor to help them.

Mr. WALKER. Well, I guess it goes to the question of whether or not we need to impose some kind of a commercial marketeer in this process. A marketeer that is concerned with the commercial side of what's going to happen in space, and get NASA out of the business. Let NASA provide the technology that does the flying but get them out of the business of being a commercial marketeer.

Mr. FTHENAKIS. Yes.

Mr. SHAPLEY. I'd like to comment on that, Mr. Walker. This is a subject that has concerned the Space Applications Board for as long as it's been in existance: the importance of getting NASA to orient itself more toward the users and the market. Partly because of the prodding from our Board, but partly because they recognized the problem themselves, NASA has for many years tried to mount various kinds of technology transfer programs—and in effect to do marketing, even though they're not allowed as a Government agency to call it that. Now, some of these efforts have had a good deal of success. Relatively small amounts of money—several million dollars a year—have been spent in attempting to do that. It is not at all clear that the R&D organization is the best one to do it; they have some able people, some of them better than others. But I think one of the advantages of commercialization, if it's done in a constructive way, would be to give us an organization which with no holds barred could go out and do the marketing. But even if that is done, I would hope that the Congress and leadership of

NASA would still recognize it is terribly important for NASA, the R&D and technology agency, to be in the fringes of the marketing business. The most futile thing of all is to have the technologists develop something that is just wonderful, that does a lot of things, and then have anybody who knows anything about the business say, "that isn't what we want at all." So, it's very important, I think, that NASA be encouraged to stay as far in the marketing, customer relation, and user relation businesses as it can, but at the same to structure the pattern of Government industry involvement in such a way that industry people can really move on out on the marketing.

One of the other difficulties that NASA has had on this has been a decision—which goes back many years—that within the Government, NASA, on space matters, is just the R&D agency and not really the civil space agency. This situation has a long history, but the result is that you have two Government agencies who have to try to be marketing agencies. First NASA, to get the user community stirred up and be interested. But now, by a very reasonable decision, NOAA, which has had much experience in operating weather satellites and is a very fine technical and operating organization, has been given the operational responsibility for Landsats. This means that the responsibility for marketing, in the case of both Landsats (and meteorological satellites, if they are involved) now really rests more in NOAA than in NASA. So not only do you have it done not too well in one place, you have it done not too well in two places. I think this is something the committee might want to look into.

Mr. WALKER. Mr. Chairman, I know I'm over my time but I have just two more questions.

Are any of you considering flying your future missions aboard privately funded flights?

Mr. YARDLEY. Are you talking about commercial launch vehicles?

Mr. WALKER. Yes. Commercial launch vehicles.

Mr. YARDLEY. I don't know of any private company that is really substantial who would take the risk of commercializing launch vehicles.

Mr. WALKER. Do you see any potential for the companies that are beginning to get involved in that of being able to generate business within industry? You represent some of the major people that would become their customers, I would think, if they do show they can fly vehicles.

Mr. FTHENAKIS. I would say I don't see that in the near future. No. I would guess perhaps 40 years from now. But in the next decade or so I don't think so.

Mr. YARDLEY. At the present time the costs of the expendable launch vehicles are still substantially greater than the cost of the shuttle. Incidentally we build one of the expendables, the Delta. The communications satellite people prefer Delta because it's easier to have their own dedicated vehicle, not sharing with other users who all have to go on the same day. But they aren't willing to pay another 50 percent or 30 percent to do it. So, I don't see how there's a viable business there.

Mr. WALKER. And finally, the point was raised a little bit ago about setting up your own shuttle as the alternative if the Govern-

ment doesn't provide room. That does get us to the question of the fifth orbiter because that might provide the space. Particularly, with the private groups that want to buy it and ultimately sell space aboard it. That seems to me to be a reasonable kind of concept and one that should get more attention than it has gotten thus far. Is it at all comparable to the example you used of the DC-3? Aren't we in the position of having something comparable here to the fact that the Government flew U.S. mail aboard the airlines for a long time to make them viable? Do we need to adopt some kind of similar procedure here—that is that the Government fly some missions, but ultimately moving toward the kinds of commercial payloads that you all seem to indicate are potential not only in the far term but the near term?

Mr. YARDLEY. There is a company who has offered to build a fifth orbiter for NASA.

Mr. WALKER. Spacetran.

Mr. YARDLEY. Spacetran. But they want certain concessions which are really difficult for the Government to give. I don't know, but with enough negotiations maybe you can work something out there. But my grapevine says it's not going to work the way it is right now.

That might be an approach to supplement the capacity, but it's just not an orbiter. You've got to have enough launch pads, you have to have enough mobile launchers, you have to have enough space in the VAB, so all of those issues get involved. I frankly don't think you need a fifth orbiter right now. NASA's strategy may be to wait for a new administration.

Mr. WALKER. I guess there's a problem there that many of us see that we face. If the fifth orbiter is not decided upon pretty quickly, the chances are you'll never get a fifth orbiter and I think that's the crisis we're up against presently. It's not a decision that can wait for 1985 or 1986 until we see whether the business develops. If we don't make the decision now we are probably going to say you are going to have to depend upon four orbiters until that time when we go to a whole new generation of space vehicle and that new generation is in competition with the whole concept of the space station and everything else. That seems to create some severe problems. Thank you, Mr. Chairman.

Mr. VOLKMER. Mr. Chandler.

Mr. CHANDLER. I have nothing.

Mr. VOLKMER. I have a few questions about things you've alluded to Mr. Yardley and I'd like for Mr. Fthenakis to verify. You all have discussed possible use of the leasecraft for the materials processing.

Mr. YARDLEY. As a matter of fact we have an agreement, I believe, that we're working together and that they know what we're doing and vice versa and the systems are being made compatible. I think one of the problems we have is a timing problem. We don't want to make big commitments before we get to the right spot in the development and testing the market. But it would be nice to have a free flyer if all that went well. He needs to get started several years ahead.

Mr. FTHENAKIS. That is right.

Mr. VOLKMER. The leasecraft. What is a leasecraft?

Mr. FTHENAKIS. The leasecraft is a project that has been initiated by Fairchild Industries. It stems from the technology of the multimission spacecraft which our company integrated for NASA. Fundamentally, what we propose to do is build a spacecraft which will be carried from the shuttle and left in orbit—low orbit. It will be visited by the shuttle. So, fundamentally you can think of leasecraft as something that extends the use of the shuttle until the next flight. It is there so that the factory can stay in orbit. The leasecraft will provide all the housekeeping facilities. We will put it in orbit. We will build it with our own funds.

Mr. VOLKMER. Unmanned?

Mr. FTHENAKIS. Unmanned. We'll lease space out to other people, like the electrophoresis people or even Government people. So, as you heard, we have a problem with timing if we are to catch the 1987 or 1986 timeframe that they want to have for their production. We must be building that spacecraft right now. But they are not willing to commit to using the spacecraft right now, so we must spend millions of dollars for something that is obviously not going to be used right away. One way to cover that gap is to have the Government, NASA for example, agree to use this craft for some of their missions to make the burden to the Government a little less; that is, they will have to spend less money for some of their missions because we will have funded the initial stages of the spacecraft. We are negotiating right at this moment with both NASA and the Department of Defense.

Mr. VOLKMER. What you are basically telling me then is that your leasecraft is basically an unmanned space station.

Mr. FTHENAKIS. That is correct. Mini space station.

Mr. VOLKMER. Depends on how you define a space station. A space station can be for all kinds of purposes and utilization. Mr. Yardley, do you want to define what in your mind is a space station.

Mr. YARDLEY. I want to make clear some of the remarks I made. I call the leasecraft a free flyer. A space station to me is manned and when I say that we could do product development five times as fast I'm saying because we can get people up there to do the development. A free flyer might even be cheaper than a space station for high production where you just put it in space and you come back in 6 months, to retrieve your product and you load more raw material. But they go hand-in-hand because the free flyers can be satellites of space stations and a lot cheaper to control and revisit.

Mr. VOLKMER. How long would you envision a person would be able to stay in a manned space station?

Mr. YARDLEY. I guess the Russians have done it for a year but they weren't in very good shape. I would think that for normal business purposes, at least 3 months before you would change the people. Over 6 months would be unusual.

Mr. VOLKMER. What other utilizations could we have? Maybe, Mr. Fthenakis, you could tell us something without describing who, has possible uses for your leasecraft.

Mr. FTHENAKIS. McDonnell Douglas as well as other companies are interested in pharmaceutical applications. There is also interest in the production of materials which are not pharmaceuticals

that can fit the same kind of requirement. I won't go into details but there are a great many people very interested in that.

Mr. VOLKMER. I'd like to get back to landsat. That seems to be taking a lot of our time today with the questions and everything. Mr. Shapley, if the Congress and the administration would pretty well go along with the idea to take all the ground operations and transfer those to somebody so that the Government could continue the flight operations in support of satellite, isn't that really subsidizing the ground operations?

Mr. SHAPLEY. Well, that would depend on what the arrangement with the contractor was. The way I think you can look at it is that you would be having a competitive contract to select a contractor to operate and do the things we have been talking about, the marketing and selling of the materials. This would be a contract somewhat similar to the kind NASA has had for many years for operating some of the facilities at Cape Kennedy, Houston, and other places—where in effect they give one company a monopoly position for a period of time. They've had a good deal of experience in that kind of contracting over the years. The way some competition has been maintained is that those contracts have been recompeted after recompeted some stated period. You can structure this in such a way that you haven't given away the business once and for all to a single contractor—and I think it's very important you not do that—and you have an expiration date. I think whether there is a subsidy involved would depend upon the terms of the contract. One of the important terms would be the price of the services that the Government buys. The Federal Government, not to mention the States and other governmental entities, will, in my opinion, always be the main customers.

In setting up this arrangement, one of the key things will be what will be the price to the Government. Another key thing: Will the Government guarantee to buy at least so much each year? I think that the contractor will want to have to have at least some guarantee of a minimum cash flow coming in.

Mr. VOLKMER. If it's going to be a continuous program somebody is going to have to tell you to put satellites up in the air to do mapping.

Mr. SHAPLEY. That is correct. Under the concept I was discussing the Government would still have to do that.

Mr. VOLKMER. At whose expense?

Mr. SHAPLEY. At the Government's expense.

Mr. VOLKMER. That to me is a subsidy then.

Mr. BROWN. Would the gentleman yield to me? I very much appreciate his probing into this and I would like to share in the probing a little bit if I may. I want to go next into the weather satellites.

We had a comparable model in the Comsat spinoff early in the communications satellite era. The main difference being there was already a mature market for communications.

Mr. SHAPLEY. Yes, sir.

Mr. BROWN. We do not have a mature market for earth sensing data at the present time. Do you think it would be feasible, and I'm going to suggest a couple of options here now and ask you to comment on them, one, for the contractor, and assume he was given a

reasonably good term, not 1 or 2 years but 5 or 10 years, to be charged with the specific responsibility for developing a mature market? That is, for aggressively marketing these products. Is that a reasonable part of a potential contract?

Second, do you think it might be feasible to divide the contract on subject matter, for example, maybe just one contractor who would specialize in the agriculture data, since we have the agristar's project moving toward a mature market fairly soon. There's the geological community which has very special needs, it's conceivable that the mineral exploration market might be a subcontract. There's the market for data having to do with mapping services. Just the delineation of the surface of the Earth, which is of vast importance to many underdeveloped parts of the world. Is that a feasible way in which we could broaden the concept so as to more rapidly mature this market.

I'm asking not for your final deliberation but just for comments on these possibilities.

Mr. SHAPLEY. I would make this comment. I think there are two kinds of contractor roles here. First, I was referring to the possibility of a sole contractor to handle the data reception and the data processing and the data marketing. Now, there's a whole separate line of business for specialized value adding companies that would specialize in the processing and sale of information of interest to agriculture and geological communities. There already are some firms doing this, but I think this is an area where there could be much growth. The concept that I was describing, for what it's worth, would have the selected contractor to the Government be barred from engaging in those activities but required to sell data at a fair and equitable price to all other entrepreneurs who might approach it to do the second phase of the work. The hope would be that the existence and availability of the data in this way would lead to the establishment and growth of companies which would be competing with each other in the dissemination of the information.

Mr. BROWN. All right. If I may just follow this for a moment. You're talking then about a two-tier arrangement in which the first contractor in effect becomes a regulated monopoly, in a sense. He's precluded from moving outside of a particular area. He is given exclusive rights within that area. Isn't this exactly what we did with Comsat, where they were limited to the international sector of communication and prohibited from the domestic market, allowing Mr. Fthenakis and others to get into the domestic satellite market?

Mr. SHAPLEY. It has an analogy, the difference being that in the Comsat case the monopoly extended to the satellites as well as to the reception and ground handling.

Mr. BROWN. Yes. But as we pointed out because there was an international communication business of great maturity, it wasn't unreasonable to do that under the circumstances. There could come a point when the market for data, Earth-sensing data, data is big enough that we could expect the original contractor to generate enough cash to support a satellite system. Would that be conceivable?

Mr. SHAPLEY. I think it is conceivable. In the first phase, when the Government is operating the satellites, the arrangements

would presumably include provisions for the chosen instrument to be paying the Government at least some part of the cost of operating the satellite. In a more mature period, the company chosen could go into the satellite business.

Mr. BROWN. If I might draw an odious comparison between this and the breeder reactor program. We've been putting money into breeder reactors for the last 30 years. It looks like we're going to do it for the next 20 years at least before we have a commercially operative breeder reactor and we're getting the private industry to contribute 10 percent on Clinch River. We're talking about something comparable here, aren't we?

Mr. SHAPLEY. I think that is a fair comparison.

Mr. VOLKMER. Now, Mr. Shapley, on the weather satellites and commercialization as I understand your testimony you seriously question the advisability of commercializing the service with the Federal Government itself as the principal customer.

In other words, what you're basically saying is that why give it to somebody else and buy it all back from them when we are probably going to end up paying more for it anyway?

Mr. SHAPLEY. Well, it seems to me that since the weather satellite system is a separate entity, all that commercialization would amount to would be to say "Instead of having NOAA or the U.S. Weather Service operate it, we'll contract that out to a private concern." Now the reason this has come up, in the deliberations within the administration we understand, is that there are those who feel that commercialization of the satellite part of Landsat is not viable by itself. There isn't enough of a market there. But the idea was advanced that if you throw the meteorological satellite and the Landsats into the same arena, then perhaps some company might find it in its interest to put up the capital to take on both tasks. This would be very interesting and is worth considering. It will be very interesting to see what the administration's conclusions on this are.

One reason that the Space Applications Board feels that this is probably not a good idea is the question of setting the price the Government should pay for weather satellite services. There would have to be appropriations to NOAA for operating weather stations and for buying weather satellite services and all that goes with that. You'll have to debate here each year what will be the subsidy for XYZ corporation for providing the weather satellite services. It just seems to us that, all things considered, there is no advantage in interposing a new way of doing business in that area.

Mr. VOLKMER. Thank you very much.

Mr. Fthenakis, in your testimony you discuss the ACTS advanced communications satellite, and had reservations about such things as being able to control, I'd say, the data that comes from it and utilizing, not for foreign competition, et cetera. How would we protect that research data?

Mr. FTHENAKIS. That's a difficult question. I don't know if I have an answer to that. The reason I mentioned that is a very vivid example I had. The chairman of one of the major Japanese communications companies, which is a good friend of mine, said to me: "You know, you people in America are very good in that field. You spend a lot of money and you create the initial ball, the core. Now, we

Japanese are good in taking the ball and making all the money." Well, I never forgot that statement.

Mr. VOLKMER. Aren't they taking the ball right now in the communicatcns area?

Mr. FTHENAKIS. Well, they are trying. They haven't gotten there yet.

Mr. VOLKMER. They're planning to get there.

Mr. FTHENAKIS. They are trying to do that.

Mr. VOLKMER. And we in our private communications satellite industry, because it is private, basically have nothing in response to that do we?

Mr. FTHENAKIS. Not that I know of. But I think there are many avenues by which one could protect this data and technology. In the past no data has been protected. But since this will be an R&D funded by the Government, I think we should protect it to satisfy the ultimate purpose.

Mr. VOLKMER. We'll it's not going to be completely funded. What the administration proposes is that a lot of the money is going to have to come in from a private contractor, whoever is the best bidder in the competition on the ACTS program.

The testimony we've heard on this from NASA was in answer to one of my questions: "Wouldn't that give whoever gets that contract and puts up that front money, wouldn't that give him a big headstart if it's successful?" A big headstart in the communications field of 5 or 6 years—whenever it is down the line.

Mr. FTHENAKIS. There's no question this contract is giving a headstart. Certainly, we're talking about a certain amount of money to be provided by the Government.

Mr. VOLKMER. Do you envision that NASA will have any difficulty in getting competitive bids for participation in the ACTS program?

Mr. FTHENAKIS. I don't think so. I think they will have competitive bids on the ACTS program. It all depends what part of the ACTS program. For the equipment, I wouldn't think they would have any problem. If one tries to imply that this will be used eventually by communications carrier for operational use while being an experimental payload, I think that will be difficult.

Mr. VOLKMER. I just want to clarify what you told me now. You say there is going to be participation. But then you point out the problem with the hardware on the ground. It has to be able to communicate and there is no backup et cetera. So will there be that much participation?

Mr. FTHENAKIS. I think there will be participation but it will be as an experiment rather than an operational system.

Mr. VOLKMER. Who's going to be putting up this money then? Who's going to put up the ground communications, the computers et cetera? $150 million, is that what you said?

Mr. FTHENAKIS. The way I view it is that it will be a limited ground segment to prove the operation rather than an extended ground segment. Now, a limited ground segment may be estabished with two Earth stations; this is, of course, something that can be done because we're talking about $1 or $2 million. But that will be strictly an experimental rather than an operational concept.

Mr. VOLKMER. Now, on the ground station operation. Would the industry contribute its own money to do those things?

Mr. FTHENAKIS. The experimental part?

Mr. VOLKMER. Yes.

Mr. FTHENAKIS. Probably industry will participate in that.

Mr. VOLKMER. Participate, but wouldn't do it solely? They would anticipate that NASA would also participate?

Mr. FTHENAKIS. Yes. I would think so.

Mr. SHAPLEY. Mr. Chairman, I think this will depend on the final details of the RFP that NASA issues. As far as I know they have not issued that yet.

Mr. VOLKMER. No, they have not.

Mr. SHAPLEY. One concept that has been discussed with us was that the Government would furnish the experimental package and the launch and associated services. The private contractor would be expected to erect the ground stations needed for the experimental part of the program and assume certain other of the costs. I think what Mr. Fthenakis is saying is this may work fine for the experiment, but it leaves open the question of whether the winning contractor really does get a headstart over the Japanese in going to an operational system.

Mr. VOLKMER. To continue on with this, how long will it be? It looks like Government is getting back into communications R&D. We were in it, we started, we got out of it and now we're getting back in it.

How long will the Government have to stay in R&D on communications?

Mr. FTHENAKIS. Right.

Mr. VOLKMER. How long will the Government have to stay in R&D on communications?

Mr. FTHENAKIS. I don't know if I can answer that question. We are in the information era. I think that as long as that information era dominates our economy, the Government has to in some way keep a hand in it to issue the provision of ingredients necessary for the long-term enhancement of this segment of the economy.

Mr. BROWN. Mr. Chairman, may I interrupt.

Mr. VOLKMER. All right. Then I have another question.

Mr. BROWN. Mr. Fthenakis, I agree with your basic position that NASA ought to be in the advanced R&D communications satellites. You justify that in your statement on page 3 with four points, which leads you to conclude that this is a minimum program in the budget which is $20 million or something like that. There are two things that arise in my mind. First the four points you raised could be cited of almost any industry in the country—any major industry. The size and importance of the industrial sector, the size of the work force involved, the need to maintain a leadership position, the efforts to establish this particular sector as a viable part. The automobile industry can make the same argument, general electronics industry, the steel industry. The question here is what separates this from these other necessary components of U.S. industrial policy? We want to maintain some degree of leadership in all these areas; we want to maintain a sound economy and full employment, and obviously satellite communication contributes to those. But, what is the unique role? We went through this study on aeronau-

tics and we concluded there is a unique reason for aeronautics, whatever it may have been. We're in the energy business, particularly the nuclear energy business in the same way. There must be something unique about nuclear energy. Is there something equally unique about this or can we make some deductions. Because personally, my bias is that we need an industrial policy in which we look at each sector of our economy and find out what is needed to insure the health of that particular sector. It may not involve any Government participation, on the other hand, it may.

The primary thing is if there's some magic ingredient which the Government can provide as needed we ought to provide it or else we become a second-rate power.

Mr. FTHENAKIS. My opinion is that it is a unique industry. It is not the same at this point in time as the automobile industry or the steel industry. I believe that the expected growth in that industry and the role it is going to play in the international scene are much bigger than any other industry.

If you look at the rate of growth and the importance of that industry from the standpoint of being able to be a leading power, it is way beyond the automobile industry.

Mr. BROWN. All right. That's good.

You're assuming a lot. You're assuming that the communications satellite business, which this particular budget item applies to, is synonymous with the information revolution which represent 50 or 60 percent of the work force of this country. And that just isn't true.

What you're saying is we ought to think about this with regard to computer, with regard to television, with regard to all of the other components, including the software industry which is also exploding at a tremendous rate. Do you mean to think that broadly?

Mr. FTHENAKIS. I will say this. You are absolutely right in the fact the communications field is a part of that industry.

Mr. BROWN. A very small part.

Mr. FTHENAKIS. However, I do not know if it is a small part. I think that probably it is the fastest growing part of that industry. It starts from a small base but it is going to be a substantial growth industry and is going to play a tremendous role. The reason is it affords a new configuration in the information industry. I would suggest that if you find the time, you read a very interesting book which has just come out, "The Megatrends," which addresses this specific problem; it has nothing to do with communication satellites so therefore it has no vested interest. But fundamentally it shows that the cornerstone of the new era starts with two or three fundamental developments in the information industry and one of them, and the primary one, is communication satellites. There are other elements and I will agree with you. I would say that since 1982——

Mr. BROWN. That raises another question. If you have a viable $6 billion industry composed of leading corporations with brilliant leadership such as yourself why can't you get together and dig up that extra $20 million, it's such a trivial amount.

Mr. FTHENAKIS. The answer to your question is probably you could. But, if you look at the industry the industry at this moment is willing to commit its resources for the next 10 years.

What I am saying is something beyond that and it is not natural for the industry to look beyond the 10 to 15 years.

Mr. BROWN. Well, the computer industry could come in with a similar request. They are a large and profitable business, you might say, and yet they are being outdone by the Japanese and other competitors just as is the communications satellite business.

The reason why the computer business, a large and profitable industry, couldn't get together on an advanced computer research program was completely different than the reasons you are offering for communication satellites. It was because of the structure of the industry, dominated by one big company; that domination is now breaking up and there are a lot of other factors at work there. But, I'm seeking some general principles here to apply to a situation and I'm not sure that I have found those general principles yet.

Mr. FTHENAKIS. Let me give you two reasons. Two obvious reasons. One, in the next decade the communications satellite will struggle to become viable because the degree of maturity of the communications satellite industry is different. It will struggle to become viable and to establish itself. Second, the communication satellite industry is different in the respect that without even being able to identify Government support it will have a substantial amount of money in research.

In addition, in programs such as integrated circuits, the Government has spent a substantial amount of money in support of the computer industry.

Mr. BROWN. Let me approach the problem from a different angle. Let me pose the hypothesis there is no future for communications satellites because they are extremely vulnerable and one military weapon will knock them all off. The real future is in hardened optical cables using laser transmission and therefore we ought to be putting research into that field rather than communication satellite. The question is one of choice. How does the Government determine how it shall make a selection.

Mr. FTHENAKIS. I think that again some of what you say is true. Satellites have that vulnerability although nobody has knocked one out of space. This will be very difficult. However, a lot of cables have been cut and terrestrial facilities have been damaged, while satellites have not been attacked yet and it is not obvious that they are so vulnerable. They are vulnerable, however, and somebody will find methods for neutralizing them. Nevertheless, to kill a satellite is a major operation.

Mr. BROWN. Not with the money we're spending on it.

Mr. FTHENAKIS. I haven't seen anyone kill one yet. I don't say that at sometime no one will, that it won't happen; it will happen. But I would not accept the premise that tomorrow people are going to go around killing satellites. That will be a major act of war, I assume, somebody killing satellites. Especially commercial satellites.

Mr. BROWN. I hope you will forgive me for belaboring this but I'm really trying to clear in my own mind, and from the standpoint of this administration as well, the policy justification for doing this. Once I feel safe in supporting a particular policy justification then we can extend that as a matter of commonsense to other applicable areas.

Mr. FTHENAKIS. I will not claim that the communication satellite is the only one and you are right there may be others. I think that it is an important one and so attention from the Government should be given. And I do not believe the request for $20 million a year or $150 million over a period of 8 years to look for the next decade is an unreasonable request.

Mr. BROWN. I agree with that conclusion. Thank you, Mr. Chairman.

Mr. VOLKMER. Mr. Yardley, I'd like to go into your area just a little bit and the space processing program at NASA. As I understand it—let me put it this way. How long have you worked with NASA on the space processing on this program?

Mr. YARDLEY. I've had very little to do with it. Mr. Rose has been doing it for some years so maybe you ought to direct your questions to him.

Mr. VOLKMER. All right. I address it to Mr. Rose. How long have you been on this program—you all have been on this program for what, 6 or 7 years?

Mr. ROSE. Yes. I first started working with the materials processing elements of NASA in 1976.

Mr. VOLKMER. All right. And have you had any difficulties in that time? Difficulties caused by turnover or anything like that?

Mr. ROSE. There's been an awful lot of turnover in that particular organization. We consummated the agreement with NASA in 1979 and was signed in January of 1980. Once we had decided to move out in a commercial vein we no longer competed on any of their particular research programs. The implementation phase of the JEA requires an interface primarily with the shuttle office.

Mr. VOLKMER. The shuttle operations office.

Mr. ROSE. Yes. And also the operations people at Houston and at Kennedy. Therefore, I've had very little in the way of interchange with the materials research office as part of the applications organization.

Mr. VOLKMER. So really that they've had the turnover hasn't caused you any problem?

Mr. ROSE. It has caused me no problem; no.

Mr. VOLKMER. You have another question.

Mr. BATEMAN. Yes.

Mr. VOLKMER. I'll recognize Mr. Bateman. He has another question.

Mr. BATEMAN. Thank you, Mr. Chairman.

I wanted to, if I may, to return this matter of commercialization. Both in the context of the Landsat program as well as the meteorological survey system. As I understand, Mr. Shapley, you are suggesting the possibilities of commercialization on aspects of Landsat. I've been sitting up here trying to categorize aspects of the program. I've done it, and probably erroneously, just as a starter, in the context of (1) you have to have a system that acquires data. That's the operational aspect of putting things up and getting it back. You have to have something to record the data. You have to have systems for analyzing the data, and fourth you have to have someone to disseminate the data for those who need or use it.

If you take that as a rational scheme of things, which elements are you saying potentially are feasible for commercialization?

Mr. SHAPLEY. With reference to your four steps, I believe the last three. From the reception of the raw data on down to the dissemination of the tapes, pictures or whatever the product is.

Mr. BATEMAN. Suppose we add another dimension to this—expansion of the technology, a refinement of the means of accumulating and expanding of the data. Where does that fit in the nature of governmental activity as opposed to a commercial operation.

Mr. SHAPLEY. In the concept which I was describing, our thought was the Government would have to stay in research and development—research and development on new ways of doing things, maybe cheaper ways of doing things, we might hope. That would not disbar any private concern from also doing such R&D and there might even be found cost-sharing ways of encouraging industry to do it or to do it jointly with the Government. But it seemed to us that maintaining effective long-term improvements and further developments of land remote sensing has to remain a Government responsibility.

Mr. BATEMAN. In your prepared statement you mentioned the recommendations of the Secretary of Commerce Land Remote Sensing Satellite Advisory Committee, chaired by Michael Halbouty.

Mr. SHAPLEY. Yes.

Mr. BATEMAN. I take it you applaud those recommendations and feel it would be constructive if those recommendations were implemented.

Mr. SHAPLEY. That report is, I believe, the only report of the current administration that has been made public so far. It came, by somewhat different reasoning, to conclusions very similar to the conclusions the Space Applications Board had come to earlier. There are differences, but by and large it sounds constructive and consistent with our views.

Mr. BATEMAN. You've articulated in your written statement, and I didn't hear you as you made the opening statement, but you have articulated the rationale at least of the Space Applications Board. Have they formalized that in terms of a written proposal or recommendation?

Mr. SHAPLEY. We have on the commercialization aspect. The written record on that is contained in a letter that we addressed to Mr. McElroy, at NOAA, I believe the committee has received copies of that letter.

If you have not we would be glad to supply it.

Mr. BATEMAN. I would like to have it. I get much paper from my committee. I won't attest to not having received it but I have not noted it yet and I am very interested in this area.

I take it that, primarily for the reason that the Government is the overwhelming dominate user, you don't see much feasibility in the commercialization of the meteorological satellite system?

Mr. SHAPLEY. That is the view that we've taken, yes.

Mr. BATEMAN. Mr. Chairman, if I may have just one moment more, and I know the hour is growing late, especially for all the witnesses who have been here all this time. If I'm taking anything away from our session this afternoon as the major thrust of what I am hearing from the private sector, it is that, as a matter of policy, it is critical to an ongoing successful utilization of a building space

technology that the private sector be assured of a continuing availability of space vehicles in which they can do their thing. I don't understand a whole lot about the things that you do, but you impress me that there are extraordinary frontiers that we are just entering and which has incredible opportunity for expansion of services, even of products that are developed in space. The key to it, as you gentlemen have given it to me, and I want to make sure I understand the major point, is continuity, assurance that if you expend your capital and exert your energies and talents in this direction that you are going to have the hardware that is essential to getting your program into space, recovering it, and using it.

Mr. YARDLEY. That's correct.

Mr. BATEMAN. How should Congress rule on this—give to the private sector that kind of assurance that you need? Is there a space continuity policy act to which you lean?

Mr. YARDLEY. I think a long range U.S. Government policy is needed. I don't know exactly how it would be developed and how you get together with the administration, but the policy should state that the space transportation system is for the whole country, including DOD, NASA, and commercial activities and we the Government have to control it, and we'll guarantee system capacity and continuity as required by all users. I don't think that necessarily takes a lot of money. It's just a question that it's a very big uncertainty.

Mr. BATEMAN. Mr. Chairman, I thank the witnesses and the chairman for his indulgences, and if I may, I have been handed a copy—this is just absolutely fantastic service—a letter from the National Research Council to Dr. McElroy and I thank you for the instantaneous communication. It came from outer space.

Mr. SHAPLEY. And we didn't even use a satellite.

Mr. BATEMAN. Mr. Chairman, if I may, and it isn't in the record of the committee, I think it might be well in light of the interest that has been focused on the commercialization issue if this were made a part of our record.

Mr. VOLKMER. This is a letter from the Space Applications Board of the National Research Council of November 30, 1982, addressed to Dr. John H. McElroy, Assistant Administrator for Satellites, U.S. Department of Commerce. If you'll provide it to the reporter, we'll make it a part of the record.

Mr. NELSON. Thank you sir. And as long as we're into that, I notice we have a NASA representative official here. I'm going to request that if she would, she furnish us a copy of the letter that's been alluded to from Budget Director David Stockman to the Administrator of NASA in regard to the operations of the shuttle and also I'd like to have an update on the status of Landsat-4 for the record.

[The information follows:]

NATIONAL RESEARCH COUNCIL
COMMISSION ON ENGINEERING AND TECHNICAL SYSTEMS
2101 Constitution Avenue Washington, D.C. 20418

(202) 334-3272

30 November 1982

Dr. John H. McElroy
Assistant Administrator for Satellites
U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Earth Satellite Service
Washington DC 20233

Dear Dr. McElroy:

This is in reply to your letter of 28 October 1982 to Clotaire Wood, Executive Director of the Space Applications Board, asking him to review the feasibility of the Board conducting for NOAA a study on commercialization of the civil land remote sensing program. In particular, you asked whether the Board would address the issue of what is the best mechanism to carry out the transfer of civil land remote sensing systems to the private sector.

Your request was considered by a working group of members of the Space Applications Board. As you know, the Board has been concerned for some ten years with the problem of moving from successful proof of practical applications of space technology into widespread commercialization. What follows is the consensus of the ad hoc group of Board members, and is consistent with the views of the Board as expressed in several major studies, in formal meetings of the Board, and in testimony by individual members of the Board before various committees of the Congress:

- Confining federal space applications activities to scientific inquiry and technological development alone, on the basis that the government will thereby have done sufficient work to allow the non-federal sector to incorporate the R&D results into commercial activities, is fundamentally incorrect.

- Major markets will not develop unless users are given the opportunity to learn how to use space data through demonstrations of reasonable duration. Industry will not invest the large sums of money required to provide the space data unless it perceives such markets.

- Having made large investments in science and technology for space applications, the federal government should be prepared to finish the job by conducting demonstrations required for the non-federal public and private sectors to provide and use the resulting goods, services and processes.

- A modest fraction of the resources being allocated to the nation's civil space program, if concentrated with skill, imagination, determination and commitment to follow through, could over time produce economic benefits sufficient to pay for the entire civil space program.

- In truncating the land remote sensing program after Landsat D-prime and relying on the private sector to continue this important work, the government is "second guessing" investment decisions about the marketplace which only the private sector can make. The Reagan Administration should have within it some particularly interested and well-qualified listeners who understand the investment problems of the private sector.

- No viable plan for transitioning Landsat to the private sector has yet come forth. Preliminary discussions between the federal government and industry have resulted in proposals in which the companies involved want essentially a no-risk arrangement guaranteed by the government.

- Complicating commercialization are issues such as proprietary use of data, international relations, regulation and others that are within the purview of the federal government only.

- Government users do now and will continue for some time to represent by far the largest segment of the market--the rest being made up of a large number of relatively small users.

- Under the circumstances, the federal government should prompt the transfer of the data reduction and data handling part of the Landsat program to the non-federal sector as quickly as economically possible. The government should also continue to conduct vigorous, innovative market-related and service-related experiments and system cost reduction programs, but for now should defer consideration of the transfer of the satellites. Such an action would require reinstating the federal commitment to support Landsat as a government research and development activity, to continuity of land remote sensing data beyond Landsat D-prime, and to continuity of research, development, test and evaluation of sensors and systems that is essential to produce the opportunity for commercialization in the future.

In the view of the Space Applications Board there has been no significant change in the commercialization situation since the expression of the views above, and the Board cannot envision any studies it could undertake that would hasten commercialization until these observations are usefully appreciated and their consequences effectively relieved.

Furthermore, the Space Applications Board is not competent (nor, in the Board's judgment, is any other single entity) to define the best mechanism to carry out the transfer of civil remote sensing systems to the private sector. In the view of the Space Applications Board, such a decision eventually must be made with consideration not only of technical factors but, more importantly, of political, social, and economic factors.

The Board believes that it is very important to the nation that remote sensing from space for practical uses continue to be strongly supported by the federal government. The space applications program, dedicated explicitly to production of new goods, services and processes, and to increases in productivity in the nation's public and private sectors, is an investment, not a consumption expenditure.

I hope that these views of the Space Applications Board will be useful in your deliberations on this important matter. The Board believes that commercialization must some day be achieved and is eager to continue its activities in ways that will assist NOAA and other agencies of the federal government to take the steps necessary to eventually achieve that goal.

Sincerely,

James W. Plummer
Chairman

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

JUN 14 1982

Honorable James M. Beggs
Administrator
National Aeronautics and
Space Administration
Washington, D.C. 20546

Dear Mr. Beggs:

Thank you for your recent letter advising us of your intentions to implement a revised Shuttle pricing policy for commercial and foreign users that would apply after 1985.

We recognize the importance of establishing as soon as possible a pricing policy for commercial and foreign users that would apply after the initial three year "introductory offer" period of the current policy expires in 1985. We are generally supportive of the proposed approach which, as we understand it, would base the minimum price to non-USG users on the additive costs of flying them on the Federal Government's Shuttle fleet. However, we believe it would be helpful to make clear the basis for our views.

The Federal Government undertook the initial development of the Space Shuttle technology based upon the projected benefits of the technology to all classes of users, USG, commercial and foreign. However, we believe that it should not be assumed that the USG should have responsibility to fund an operational system with sufficient capacity to meet non-USG needs once the Shuttle technology is developed.

Generally speaking, when circumstances justify the funding and management of an operational system by the USG that is also sought by non-USG entities, the USG should limit its role to making available system capacity which exceeds its own needs. The price at which this capacity would be made available to commercial and foreign users should then be established so as to minimize the overall cost to the Federal Government of meeting its own needs in the long run.

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We understand that the lowest costs per flight to meet long run USG needs may be achieved by utilizing the excess capacity of the Shuttle system. Given the projected "learning curve " benefits as the Shuttle transitions towards routine operations in the mid-1980's and the expected excess capacity of the Shuttle system over planned USG flight rates, it would seem desirable to have the excess capacity used by commercial and foreign payloads.

On this basis, the appropriate price for excess Shuttle launch capacity after 1985 would appear to be the one that:

- Is the highest price at which sufficient users will be available to utilize the excess capacity of the Shuttle system after USG user needs are met.
- At least covers the additive costs of the USG to operate the Shuttle system for non-U.S. Government users.
- Does not in itself lead to the demand for funding of additional capacity by the USG (e.g., additional orbiters, ground support systems).
- Does not discourage or compete unfairly with possible private sector initiatives that would invest wholly or partially in Space Shuttle technology in order to service growth in the commercial and foreign user market.

As we understand it, the proposed pricing policy would price the Shuttle system at additive costs during the 1986-1988 period, with the expectation that productivity improvements during the period would allow the subsequent price of excess capacity to commercial and foreign users to be on a full cost basis without any significant increase in price.

It appears to us that it is possible to begin now to implement the proposed approach and remain consistent with the principles we have noted above. Therefore, we believe it would be appropriate to allow now for yearly adjustments to the pricing guidelines that would apply after 1985 in the event that either of the following conditions is projected to occur:

- Commercial and foreign demand for Shuttle launches appear sufficient to allow a price higher than additive costs and still fully absorb excess Shuttle capacity (e.g., problems with competing alternatives, or unexpected attractiveness of the Shuttle at additive cost pricing).
- Problems with the Shuttle and the priority needs of USG users indicate a likely curtailment of the excess capacity of the Shuttle.

We, therefore, recommend that the new pricing policy be implemented, subject to the above considerations, so as to encourage early private sector investment and to retain the flexibility to make future periodic price adjustments for commercial and foreign users so as not to restrict the Administration's options in the future funding of the space program.

Sincerely,

David A. Stockman
Director

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

JUL 2 1982

Honorable David A. Stockman
Director
Office of Management and Budget
Executive Office of the President
Washington, DC 20503

Dear Mr. Stockman:

I was very pleased to receive your letter of June 14, 1982, which supports fundamentally the implementation of our revised Shuttle pricing policy for commercial and foreign users. We agree on the basis for establishing the price which includes a substantial margin over estimated costs to ensure that the U.S. Government will not incur additional costs for launching non-U.S. Government missions. However, our fixed price is based on an estimated average cost over the period 1986-1988 and will apply to launches during that period. We have taken this approach in order to provide a firm planning base for users, many of whom must design payloads for launches over several years and require some assurances that the launch cost to them will be stable for a reasonable period of time.

I feel confident that the policy we have developed will provide the Space Transportation System a competitive position relative to foreign expendable launch vehicles and that it preserves the basic principle of maximizing cost recovery to the U.S. Government.

Sincerely,

James M. Beggs
Administrator

STATUS OF LANDSAT - 4

March 1, 1982

Background: Landsat-4, launched in July 1982, has two sensing instruments and three transmitters for sending data to Earth: The MultiSpectral Scanner instrument (MSS, which was also on Landsats 1, 2, and 3) sends data through an S-band transmitter directly to ground stations. The Thematic Mapper instrument (TM, which is new and more advanced then MSS) sends data through an X-band transmitter to the ground. Both instruments can send data to Earth indirectly through the Tracking and Data Relay Satellite System (TDRSS) by means of a Ku-band transmitter once TDRSS is launched and operating. Landsat 4 was launched in July, 1982.

The Problem: The problem has been in the X-band transmitters. There are two redundant transmitters; one failed earlier and the second failed last week.

There is a chance that the problem could be corrected.

Each transmitter has 4 subparts which can be used separately. Thus, if two different subparts have failed, it might be possible to work around the failed subparts to make a working transmitter. So far this has not been achieved.

There is also some chance (and some belief on the part of NASA) that the problem may lie in the software, i.e., in the computer commands through which the satellite is operated.

These and other options are being checked out using Landsat D-prime, the identical follow-on satellite which is to be launched when Landsat 4 fails.

As of now no TM data is reaching the ground. After STS-6 is launched, TDRSS will become available and will transmit TM data for the fraction of the Earth seen by TDRSS. However no ground station will be able to receive TM data directly.

For further information please contact Radford Byerly on 225-8102.

I have a final question. I do appreciate you taking all afternoon to be here but it's been very informative. Now, we did have a technology transfer program within NASA and which we no longer have. We have had a technology utilization program in which last year NASA proposed to reduce to $4 million, then Congress decided to keep that at $9 million, they came back this year with another $4 millions. I'd like to know your position on the technology utilization program. How do you feel about it?

Mr. SHAPLEY. The technology utilization program, as you know, is primarily directed at transferring NASA developed space technology to other uses. As such, it does not come very often within the scope of the Space Applications Board. On the other hand, the Space Application Board has been very interested in the technology transfer program. Technology transfer is the name that was at one time given to the type of activity I referred to in my statement about NASA and the users. In this program, NASA would get itself educated as to what the users wanted, would spend some money in an experimental and promotional way to have users undertake an experiments they might not otherwise be able to do. In the view of the Space Applications Board, this type of activity was very useful. We would hope it could be continued.

Mr. YARDLEY. I haven't had much firsthand experience with either program, but from what I've heard they haven't been effective and I don't know why.

Mr. FTHENAKIS. I have the same comment.

Mr. VOLKMER. No further questions. I want to thank all of you very much for being with us and we appreciate your time and your testimony and the committee will stand adjourned until 1:30 p.m. on March 1, 1983.

[Thereupon, at 4:15 p.m., an adjournment was taken until March 1, 1983 at 1:30 p.m.]

FIELD HEARINGS

FRIDAY, FEBRUARY 25, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Johnson Space Center, Houston, Tex.

Chairman VOLKMER. The subcommittee will come to order. I'm pleased to be here with Congressman Lujan and Congressman Andrews at the Johnson Space Center which has contributed significantly to the success this Nation has obtained in manned space flight.

The subcommittee is currently reviewing the NASA fiscal year 1984 budget request, and the briefings and discussions today will become a formal part of our hearing record. We look forward today to gaining a better understanding of the overall mission and capabilities of Johnson Space Center and the problems which the center management perceives in accomplishing this mission.

We expect to review the current status of shuttle activities, particularly those parts for which the Johnson Space Center has primary responsibility.

Again, we appreciate the opportunity to be here. Thank you for your efforts in preparing these briefings, and I'll yield to the gentleman from New Mexico who will make a short statement.

Congressman. LUJAN. I have no statements, Mr. Chairman. I'm just real pleased to be here. The only times that we've been here before has been during times when the Orbiter is out in space, and we're watching it and listening to all the communication. These trips where we come to get updated on the program, how everything is going, plans for the future; those are the trips that enable us to do our work a little better. So I'm pleased to be here to get briefings on these various aspects at the Johnson Space Center. Thank you.

Chairman VOLKMER. Does the gentleman from Texas have any statement?

Congressman ANDREWS. I just want to thank everybody for the opportunity to come back again. It's a pleasure to be here as a Congressman and not as a candidate. You all have always been so polite and gracious to me, and I'm looking forward to today's briefing.

I think what is significant about today is that we do have the chairman of our subcommittee and the ranking minority leader on our subcommittee, and I think that's indicative of a commitment the subcommittee has to the Johnson Space Center and the important role that it plays in our overall space program. I look forward

to working on this committee and working with all of you here at the Space Center to move forward through the eighties.

Chairman VOLKMER. Then we can begin and I now recognize Mr. Griffin to make his presentation. I see we have a copy of a prepared statement. We can review that or that will be made a part of the record at this time; or you may use a synopsis, however you so desire.

Mr. GRIFFIN. Before I begin, I would like to turn it over for just a second to Mike Weeks, who is the Deputy Associate Administrator for space flight at headquarters who has a couple of things he would like to say.

Mr. WEEKS. Chairman Volkmer, Mr. Lujan, and Mr. Andrews, I think that all I'd like to say is that you are at one of the crown jewels of NASA and the United States of America. The Lyndon Baines Johnson Space Center grew out of the space task group which was organized in October 1958, after President Eisenhower started and put into law the Space Act which created NASA in about June 1958.

So this organization here at Johnson Space Center which grew out of those 25 people of the space task group in October 1958 has done some rather first-class things, like the Mercury program, like the Gemini program, like the Apollo program, and like the shuttle program, the orbiter, and so forth. So this particular organization which started with its first center director, Bob Gilruth, in October 1958 is now followed through with its third, Chris Craft being the second, and now Jerry Griffin being the third center director in a quarter of a century of this country's doing space business.

So in many ways, this American experiment of putting things into space and landing 12 people on the Moon in about 12 years after they started is an accomplishment that very few things in the history of mandkind have done so well. So we are very proud of Griffin and his crew and their part in the space flight program. That's all I have.

Mr. GRIFFIN. Thanks, Mike. Mr. Chairman, if it's all right with you, I think I would like to submit my statement for the record and give you a synopsis of it. I do have some charts that I'd like to go through.

First of all, I'd like to say welcome to all of you. This is my first field hearing since I have been back at JSC.

Chairman VOLKMER. If I can interrupt, this is my first year here.

Mr. GRIFFIN. Let me introduce the other witnesses that are going to speak to you this morning after I finish. On my right is Dr. Glynn Lunney, who is the program manager for the space shuttle. Arnnie Aldrich is not with us today, but his deputy, Tom Moser, will be speaking to you about our specific responsibilities with the orbiter itself. Mr. George Abbey is the director of flight operations will speak today about some of our astronaut situations and what we're looking forward to the future there.

Later, you are going to be touring Ellington Air Force Base; and, most of that, as far as Johnson Space Center is concerned, is under George's responsibilities. So you will be hearing from him throughout the day off and on.

To George's left is Clarke Covington, who is our acting manager of our space station project office. To some degree, I think that's

probably a misnomer. The agency has chosen to call it that. I would say right now that we cast that more as a permanent facilities in space project office, and I believe it's probably a little early to specifically call it space station. That's the monitor we put on it, but you will hear from him about some of the advanced studies work that we are doing about permanent facilities in space.

Mr. BRANSCOME. Space or land.

Mr. GRIFFIN. That's correct.

We've had a busy year since the subcommittee was here last. We've flown three flights, all very successful, and we are about to fly a flight sometime in the month of March. We think right now somewhere around the 19th is the most likely launch date.

Probably in the last year, our most significant thing that we have done flightwise has been the fact that we have delivered two commercial payloads for paying customers to orbit, and we are about to now, with the sixth flight, fly a new upper stage, which we'll hear a little more about today--Glynn is going to go into some of that—and we're about to create a number of other "firsts" in this next year. You will hear about those throughout the day, so I won't go into those right now.

I would say that by and large the state of the Center is good. We are progressing about the way we wanted to as we had planned for some years. We've got our problems in terms of budget constraints and people constraints, but they're the kinds of problems that a Government manager's got to work with all the time.

Thankfully, our hardware so far in the space shuttle program has operated very well. It has met or exceeded our expectations on almost every account. We have had a problem with this launch in terms of delaying it because of the hydrogen leak that you're going to hear something about today. You'll probably hear some more of that at KSC when your travels take you there. Surely, you will hear about some of it at Marshall as you visit them.

We will give you a broad view of that and where we stand, and like in any situation where you have a problem, you learn from it. We've learned quite a lot from this one, and I believe the program will be, at the bottom line, better off for it, particularly occuring now rather than later.

With that, so that I don't get too much into what you're going to hear from the other witnesses, I would like to go through some charts with you and discuss Johnson Space Center as an institution and how we fit into the bigger picture.

[Exhibit A-1.]

Mr. GRIFFIN. Let me have the first one, please. Johnson Space Center, as Mr. Weeks said earlier, began here in the early 1960's shortly after NASA was formed. The Space Task Group moved here from Langley, and we actually occupied this facility in 1964. The elements of the Center, however, were in Houston as early as 1962. We were spread out in office buildings all over town, and then we finally settled on this bit of property, 1,600 acres.

The building that you're in right now is this building. We're on the ninth floor. As you can see, there are a number of facilities, some of which you will see today, the key facilities that you will visit; and I want to go through a large explanation of these. But suffice it to say that although it is 20 years old, we still have some

of probably the most unique facilities in the country in terms of space research and development kinds of capabilities. We actually have another facility that is under our control, and that's at White Sands. Mr. Lujan, I'm not sure you've been there; I suspect you have. The White Sands facility reports to us. I'll discuss a little more about what they do a little bit later, but it's a unique facility in itself, just north of Las Cruces in the White Sands area, and it's still very active for us, active in the shuttle program.

Congressman LUJAN. Are most of the buildings laboratories?

Mr. GRIFFIN. I would say probably on the order of 40 percent are technical facilities—40, 50 percent or about half are technical facilities; the other half are office space or are administrative areas. If you might imagine, at a facility of this size, we've got, for instance, in terms of warehousing, there's quite a lot of storage of things and materials. But on the order of 50 percent are technical facilities.

[Exhibit A-2.]

I thought it would be good to show how we fit into the bigger picture. We made a try today to stay away from abbreviations and acronyms, and if I say some, if one slips in, stop me. We speak a strange language, as you know; so I'll try to keep from doing that.

I believe in Washington you've already heard from the Administrator, of course, in his testimony. I believe Dr. Edelson, Associate Administrator for Space Science and Applications, has spoken to you already; Dr. Kerrebrock has, and I believe Ed Smylie has already testified. These Associate Administrators are the operating vice presidents, if you will, for the Administrator to carry out the programs that the Agency is responsible for. We fall under the Associate Administrator for Space Flight. Lieutenant General Abrahamson, who is on detail from the Air Force, runs that organization. I think you are going to hear from him in testimony next week.

Congressman VOLKMER. We met with him yesterday.

Mr GRIFFIN. Very good. The field centers all fall under—and these are the field centers for NASA right here—an Associate Administrator in terms of reporting channels. We fall under Lieutenant General Abrahamson, and we are one of four facilities: the Johnson Space Center; Kennedy Space Center, the launch site; Marshall Space Center, which is another development center not too much unlike JSC, Johnson; and then the national space technology labs in Mississippi, the reason, the center of gravity of that organization is still aimed at our engine testing, and our engine test stand is there. So as a result, all four of these are what we call the space flight centers. Now, it so happens—and you'll hear a little about this during the rest of the day—we also do work for the other Association Administrators; here, here, and some here. But what has happened here is each one of the centers has been assigned to the Associate Administrator that is most involved in that center's activities; and as a result, they have both the institutional responsibility as well as the programmatic responsibility. So we work with Lieutenant General Abrahamson, and Mike Weeks, and his people virtually on a daily basis in carrying out the space shuttle program and any other program that we are responsible for here at JSC.

Congressman LUJAN. Could I ask a question? It becomes more clear looking at a chart depicting what the laboratories do. In the particular case of this Associate Administrator, then, would you say it's the whole space transportation system, and only that; and then the aeronautical one is the research for new kinds of airplanes and that sort of thing?

Mr. GRIFFIN. Yes, that's exactly right.

Congressman LUJAN. The first one is space that is not manned, I guess?

Mr. GRIFFIN. Well, it can involve man. As a matter of fact, these people are heavily involved, for instance, in the space lab which will fly in the rear of the Space Shuttle, and they are involved in manned activities. But they are specfically responsible for the science and applications uses of space, where we are involved primarily in the transportation, getting us there and back.

Chairman VOLKMER. Would you say operations for—add operations with it?

Mr. GRIFFIN. Well, not exactly. The operations were probably more centered here in operating the system. But in terms of operating—let me give you an example.

When you put a satellite out of that orbiter and it becomes operational, yes, then these people are involved in that kind of operation—unmanned satellite operation.

In terms of operating in the transportation system, however, it falls over in this area.

[Exhibit A-3.]

Now, a similar chart of Johnson Space Center itself. We're typically organized much like many of the NASA centers. I'm not going to go through all of this, but I wanted you to recognize under the director, we have a staff function much like you saw there at the Headquarters organization—a number of staff functions. We have project offices. You're going to hear from these areas today.

Unique at Johnson Space Center, though, is the Space Shuttle Program Office, and that's a difference you should zero in on to some degree. The shuttle program was assigned to Johnson Space Center back in its inception, what we call a lead center concept. And as a result, the program responsibility here at JSC covers projects that make up the program, one of which is the space shuttle orbiter, which Johnson has responsibility for.

The [tanks] the external tank—this big device here—the solid rockets, the engines—all are performed by Marshall Space Flight Center, and there are project offices under those. Functionally, they are responsible to Dr. Lunney as the program manager. Now, institutionally, they're responsible to their own center directors, but in a programmatic sense, they are responsible in a channel to Dr. Lunney. The Kennedy Space Center has its own project office, and it's called launch and landing, which fits exactly what they do. And, again, functionally, they respond to Dr. Lunney's direction, who, in turn, responds to not only headquarters for programmatic direction, but to me from an institutional angle. He's going to show you a little more how this wiring diagram fits together, but it's a little bit complicated. There is one center, JSC, who has this programmatic responsibility to wrap up all the projects in the field

and make sure thay all play together. Basically that's what it amounts to.

I'm going to talk a little bit—and you're going to hear a little more—about here at Johnson; this is where the bulk of the work is carried out and it's where the bulk of the people are.

[Exhibit A-4.]

I'm going to tick through these, and I'm not going to go through every line; but, for instance, in flight operations, this is the organization right here and George Abbey heads it. This is where our astronauts and our flight controllers reside in the Mission Control Center. It's where they are trained; it's where we do a lot of our flight planning, for instance. It is the flying operations aspect of space flight in the shuttle.

George also has quite a responsibility in terms of flying aircraft, and those fall into several categories. We have shuttle training aircraft where the astronauts actually train to land, and you'll probably see that out at Ellington today. We have two of them. We have the shuttle carrier aircraft which carries the orbiter when it lands in the desert and carries it back to Florida. That's under George's responsibility. We also have several T-38's which the astronauts fly for proficiency flying in order to maintain their flying skills necessary to fly the oribter.

Congressman LUJAN. How many T-38's do you have? We were wondering about that yesterday.

Mr. ABBEY. We have 26.

Mr. GRIFFIN. We've got some of the oldest in the fleet, too. We've had those airplanes for about 20 years, I guess; but they continue to fly and fly well.

[Exhibit A-3.]

So the flight organization, the number you see right there is the number of civil servants assigned to that organization.

Probably the biggest number of these are involved in systems and flight control functions during the mission in the Mission Control Center, and you'll see a little more of that later today.

[Exhibit A-5.]

Engineering and development is this organizatin right here. It is the engineering strength of the center. It is where we—and I'll let you read through some of the words there, but it is where we perform our engineering function for the space shuttle program as well as all other space transportation. Advanced programs, things of that sort, new kinds of techniques, advanced technology: That work is carried out in our Engineering and Development directly. It's been one of the strengths of JSC for many years. It continues to be, and we're watching that very closely in terms of skills erosion as we move forward. I'm going to talk a little more about that toward the end of this briefing.

[Exhibit A-6.]

Two other organizations: One of the organizations, I should point our first, Director of Data Systems and Analyses. It's a large organization; it deals with our design and implementation of all of our ground systems. As you might imagine: Mission Control Center, our simulators that we train our astronauts with, our data systems, some of our mission planning functions, and this is this line right here, mission profiles.

As we start to fly a mission or plan a mission, we must plan trajectory very carefully. As you might imagine, it takes a fair amount of computational capability, which these folks maintain, to plan these different trajectories and orbits, deorbits, landing sites, lighting conditions, et cetera; and these folks are the ones that are responsible for that.

I mentioned White Sands earlier, shown here. Primarily, our facilities there are aimed at testing. We've done a number of testing of our reaction control system, rocket engines, and we have done a number of plane propagation testing out there. In fact, it's probably one of the best in the country for testing the way planes propagate through different kinds of materials. Not only have we done that for our own space work, we have actually done that work for the FAA, the military on aircraft interiors, and things like that. We have done quite a lot of reimbursable work there. We get paid for that; but it's a unique facility. It has some unique capabilities that you just don't find around the country. So we're making use of it for other agencies when they call for it and when we can support it with reimbursable kinds of work.

Congressman LUJAN. What does "highly sophisticated cleaning" mean?

Mr. GRIFFIN: Some of these facilities out there are aimed at the cleaning of very critical valving and components in propulsion systems. It's not the kind of thing that you can just flush it with alcohol or something. They use Freon, some rather exotic ways to clean materials. Does anybody else here have some good feel for some of the things they've done lately?

Congressman LUJAN. Is that for refurbishing after a flight or something?

Mr. GRIFFIN: Yes, it could be.

Mr. ABBEY. It was used on cleaning of our sample tools and things like that.

Mr. GRIFFIN: To clean our sample tools before we went to the moon; I guess that's a good example.

Joe, anything else that you can think of?

Mr. LOFTUS. Well, those are the primary things. Cleaning of things where you're going to expose these materials to high pressure and oxygen or something like that where you simply cannot afford any kind of organic contamination. They use Freons, distilled water, and they have very exotic inspection techniques using ultraviolet radiation and things of that variety for measuring the cleaning as well as actually achieving it.

[Exhibit A-7.]

Mr. GRIFFIN: OK. The other organization I wanted to mention here, down in this line, is the Director of Space and Life Sciences, which is where our work is carried out in biomedical areas, crew health areas. We are involved still with lunar sample analysis, and those samples are still here in a facility especially built for them. Earth resources applications work is still done here, and we're involved in lunar and planetary sciences. I'm not sure anyone has yet briefed you, and we won't go into it today; but the Lunar and Planetary Institute is just offsite here, and a number of those activities there are interactive with our group here. They are not actually a part of JSC; they're just offsite, but it was established by

NASA back in the order of 13, 14 years ago. The Shuttle Program Office, I'm not going to mention too much about it. Glynn Lunney is going to fill you in on that; but, again, it's the overall systems management of all the shuttle flight hardware. And then specifically JSC is responsible for the design, development, test, and production of the space shuttle orbiter, the airplane use of the space shuttle. You'll hear more about that, too.

Congressman LUJAN. Have you analyzed all those rocks and everything that came back?

Mr. GRIFFIN: Still in the process. Many of those materials—a lot of that is done by outside researchers who come into our facilities. Those materials are still being sliced, dissected, thin sliced, studied, and there's still a lot of information. We've probably got—the total pounds of about 800 pounds of materials were returned from the Moon. Very little of it has been destroyed, that is, by having to cut into it and that sort of thing. Lots of stuff have been cut up and analyzed, but we've lost very little of it. It's a national treasure. We're very careful with how we treat it. Much scientific research is still going on with it.

Congressman LUJAN. Are there published studies on it?

Mr. GRIFFIN. Oh, yes. We can provide some of those for you if you would like.

[Exhibit A-8.]

Program operations is an organization that takes some of the common things of our program and project offices that need to be done, configuration management and some of these kinds of functions here; and we've brought those into one organization. We may, in the not too distant future, break this up and redisperse it back to the project offices. At one time, 10 years ago, it made sense to pull it together because we had a number of different projects in the center that required that kind of expertise. Today, we can probably do it a little differently, and we're looking at ways to streamline that operation. But today, we've still got that.

Then, of course, safety, reliability, and quality assurance is a function at NASA that's been stressed for years and years. If we are to fly successfully, we must also fly as safely as we can. This organization has been about that strength for a number of years and does an outstanding job of keeping us honest and making sure that we don't make mistakes.

[Exhibit A-9.]

Finally, these three organizations are what I call the administrative or the supporting orrganizations here at the center. I will let you read through those. They're not small organizations. Center Operations keeps this whole place running. Administration and program support is all of our contracting support, all of our financial management, et cetera. The big function is to keep the center running. And then we've got a number of staff offices that I mentioned earlier that make this place tick.

[Exhibit A-10.]

A little bit on budget, and this is—again, I'm not going to go through all of this. For fiscal 1983, our operating plan shows a total of the year runout of about $1 million—$1.8 billion, and that includes all sources of funding: Research and development, which is a major title; research and program management, which is primarily

our own in-house cost of people in facility services; and construction of facilities, which is relatively minor, $3.5 million in 1983.

I have not seen the final projection of the numbers that were sent to the Hill, but this bottom number is on the order of $1½ billion for this summer. We're down some because we are passing peak of the shuttle funding. That remains to be seen for 1984, yet, in terms of what the Congress approves and how the final operating plan is pulled together; but it's on that order.

[Exhibit A-11.]

I'm going to show you some pie charts now that put some of this into perspective. Of all of NASA's R&D budget, Johnson is approximately—represents 30 percent of the expenditure by the agency. This is Marshall, I believe. I wanted to show you that's 28.5 percent, and these are just about equal portions there. The rest of this is spread amongst the centers, and that gives you an idea that between the two of us, we represent about or handle the expenditure of about 60 percent of the agency's R&D funds. Of couse, the biggest share of that is the shuttle today.

Congressman LUJAN. You're talking about the $1½ billion?

Mr. GRIFFIN. No, I'm talking a higher number than that, Mr. Lujan.

Congressman LUJAN. That's the total R&D?

Mr. GRIFFIN. Total R&D for the agency is approximatly $5.8 billion.

Congressman LUJAN. Well, the total budget is right around $7 billion.

Mr. GRIFFIN. Right. Mike, can you help us there?

Mr. WEEKS. R&D is about $5.8 billion.

Mr. GRIFFIN. Yes, R&PM is a little over $1 billion and construction is small; so it's on the order of $5 billion, and of that, we spend about 30 percent of that, which is about $1.5 billion.

Mr. WEEKS. I think you should remind the congressional people that this is the budget to the Nation and to the Congress, but Mr. Boggs totally spends about $900 million more than that, and the space flight about $500 million more than that because we get a lot of reimbursement here.

[Exhibit A-12.]

Mr. GRIFFIN. OK. Here's the Johnson Space Center itself which I wanted to put into perspective for you. Space transportation, which is what Mike and his boss are responsible to General Abrahamson, represents about 96 percent of our R&D budget here at the center. And we've got small amounts in space science, a very small amount of aeronautics and space activities. So, by and large, we are space transportation, which is the point that I made at the beginning.

[Exhibit A-13.]

The R&PM budget, which is research and program management, but it's another way of saying it's our inhouse cost. Personnel and related costs, which are salaries for our inhouse people, represents about 70 percent of that. We've got some contractors that we provide out of R&PM, research and program management's piece of the budget, and we've got some management and operations functions that we also go to contractors. Then we've got travel and some technical services.

That spread or that percentage has fallen constant just about at those levels for at least the past 10 years that I know of. I think you'll find this true at just about all of the centers of today.

[Exhibit A-14.]

[Exhibit A-15.]

A little bit about the people. As you can see, this is distribution of people by programs, and you can see that the lion's share, which makes us our budget of our civil service manpower strength, which is 3,287, is devoted to space transportation, about two-thirds. The interesting thing of that is that of our 3,287 inhouse civil service manpower strength, about two-thirds of those are scientists and engineers. I'll come back to that in a minute, but we are a highly technical organization as you might expect, and that's the way we kept it; that's the way we want to keep it. It does cause us some problems in the long haul in terms of making sure that we retain the right kind of skills. I think my next chart will fit into that; but as you can see here, aeronautical research, we've got five people, a very, very small number, so I didn't want to have anybody feel like we do a whole lot of aeronautical research. But we do pretty much hit all of the different program areas at headquarters, some of them fairly significant numbers, but, again, the lion's share is back here in the space shuttle.

[Exhibit A-16.]

I think my last chart is having to do with skills. I wanted to show you what the average age since 1968 at the center has been. We had a period back in the late sixties, early seventies where the agency average age was increasing very rapidly; in fact, it went better than 1 year per year for awhile. That trend finally reversed as we were coming down the attrition curve after Apollo, our average age grew because in some cases we actually had reduction in forces where we actually lost some of our younger people; so that drove up some of the average age fairly rapidly. Then we got to a period when we had a little stability, and I'm happy to say that at least in fiscal 1984 we've got a good stability. This is out of O&B that we are not going to have to cut our civil service manpower strength this year in 1984.

What that allows us to do is it allows us, as people retire, we can take college fresh-outs, college recent graduates, which in that scientific and engineering field, it is very important that we continue to revitalize ourselves with people that have the latest skills, the latest technologies that are being taught; and even at that, though, our average age is sitting here at 43.6 today. I think we may be able to hold that about there for the next year. I'm interested to see when the President's retirement policies are finally described what effect that may have on us. If people must stay longer, it's possible, I think, that we could see this average age get alarmingly high. There's nothing wrong with age, but in this scientific and engineering fish bowl that we live in, we do need to be able to keep hiring the recent college graduates.

Congressman LUJAN. Don't you think we could go into more contractor involvement as we are at Kennedy? Isn't that probably the wave of the future?

Mr. GRIFFIN. Undoubtedly, as the shuttle program matures, I believe that we will see a gradual increase in contractors; however,

we've still got to maintain, in the long range, technology skills and the skills to manage those contractors.

Congressman LUJAN. Yes; but we've done that in DOE where the laboratories and all the facilities are managed by contractors rather than managed by civil service. I'm just saying that's one way to cure that problem, because I really believe that we will see higher retirement ages before this whole thing is over.

Mr. GRIFFIN. I believe you're right; it will go up. I'm not crying doom here; I'm just saying that it's something that we're watching very closely because the way we carry out the space program today, particularly new programs, and in an operational setting, obviously, I believe the STS will gravitate toward more contractual involvement. But as we talk about new programs, we're not sure we can turn that over to the contractor work force. Now, a lot of that depends on the role of the Government and the space for the future, which is obviously up for review constantly.

We're not saying that just because we do it this way, that that is the only way to do it. But as long as we continue to do it the way we do it, I think we must pay attention to make sure our work force is viable and that they're the best in the world. Today, we do. I think there's no doubt about it; we've got the best work force in the world available to do this kind of high technologic pushing back of the frontier.

Congressman ANDREWS. What is the turnover rate at Johnson Space Center?

Mr. GRIFFIN. Well, I think the economy has had something to do with this, but it has fallen quite a lot in the last year. I think we were projecting, what, 100 losses this year? Does anybody have that number?

Mr. LOFTUS. One hundred and eighty.

Mr. GRIFFIN. We've seen a very, very small number of people leaving, probably because there's not a whole lot else to do.

Mr. ABBEY. Which means you can't bring very many in, either.

Mr. GRIFFIN. That's true. I don't want to leave you with the impression that we have not been in the business of hiring college fresh-outs, because we have. We've been quite fortunate here at JSC.

Congressman ANDREWS. What kind of activities do you have in recruiting around the country?

Mr. GRIFFIN. We have done a lot, and we might want to provide you something for the record on that, Mr. Andrews. We can do that and give you some ideas on how we go about it, but we send recruiting people out to the universities, and we have no problem of attracting people, even though sometimes we do—and the history that the starting salaries in the commercial side are higher than the Government. People still want to work in the space program. A lot of our people come through the co-op program, where we have people for work experiences and then send them back to college for a semester and then back to work experience. We retain a very high level——

Congressman LUJAN. Explain that a little bit. How does that work?

Mr. GRIFFIN. It's a work-study kind of program where a student goes to school for a semester—I think he has to be in his junior

year; you do it the last 2 years. I think Glynn was one of the original co-ops at NASA. But he'd go to school for a semester; then he works for us for a semester; and then he goes to school and he works alternately.

Then at the time he becomes a graduate, if we like what we've seen and he likes or she likes what she's seen, we generally get together for a permanent offer. It's quite beneficial to the students; it's quite beneficial to us. We have those both in science and engineering, and we do have some administrative co-ops.

Congressman LUJAN. Where do they come from?

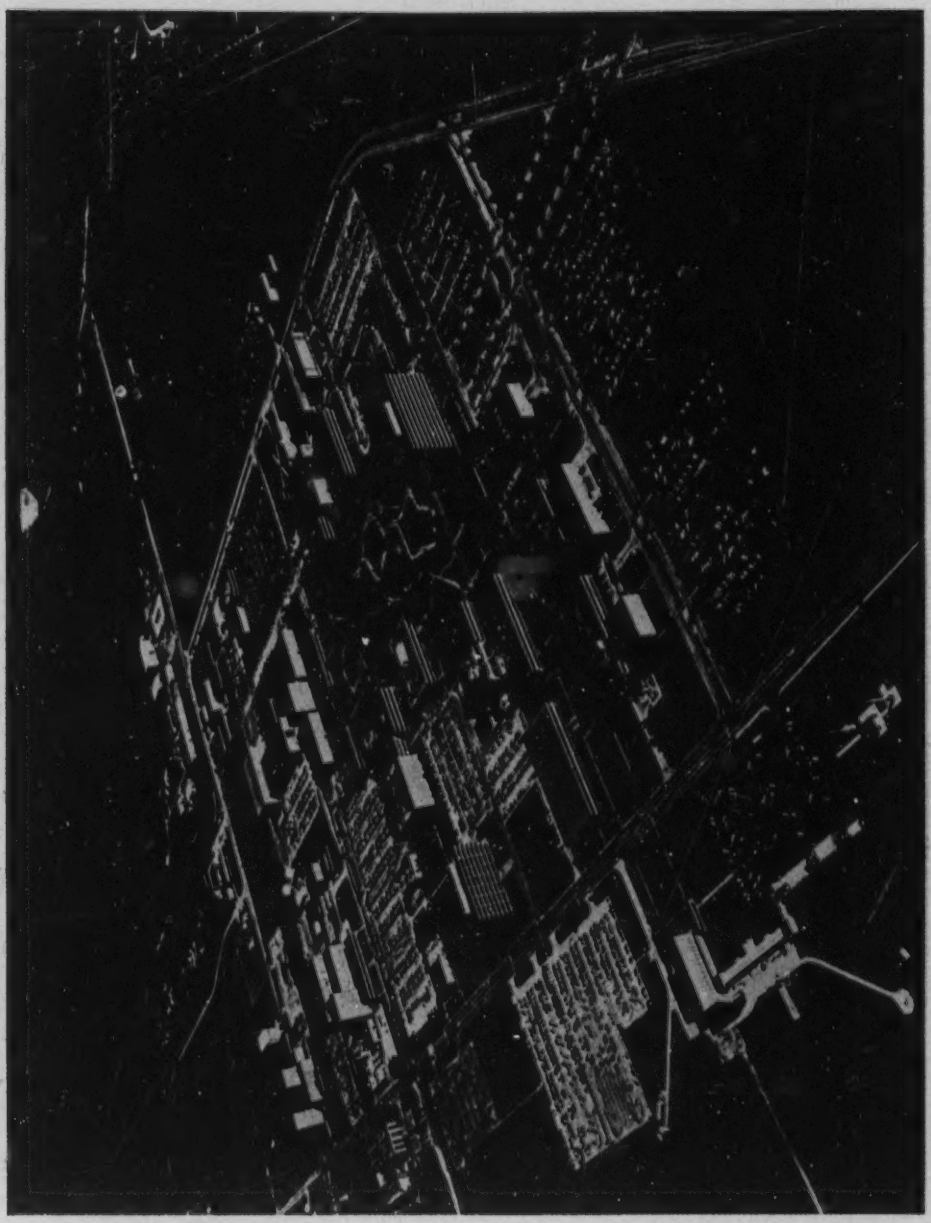
Mr. GRIFFIN. All over the country. I think, if I had to guess—and Jack Lister is not here—but I would guess probably half or three quarters are from schools in New Mexico, Oklahoma, Louisiana, and Texas. You've probably got a good share of them.

Mr. GRIFFIN. All right. With that, I'll turn it over to Glynn Lunney who is going to talk to you about the space shuttle program.

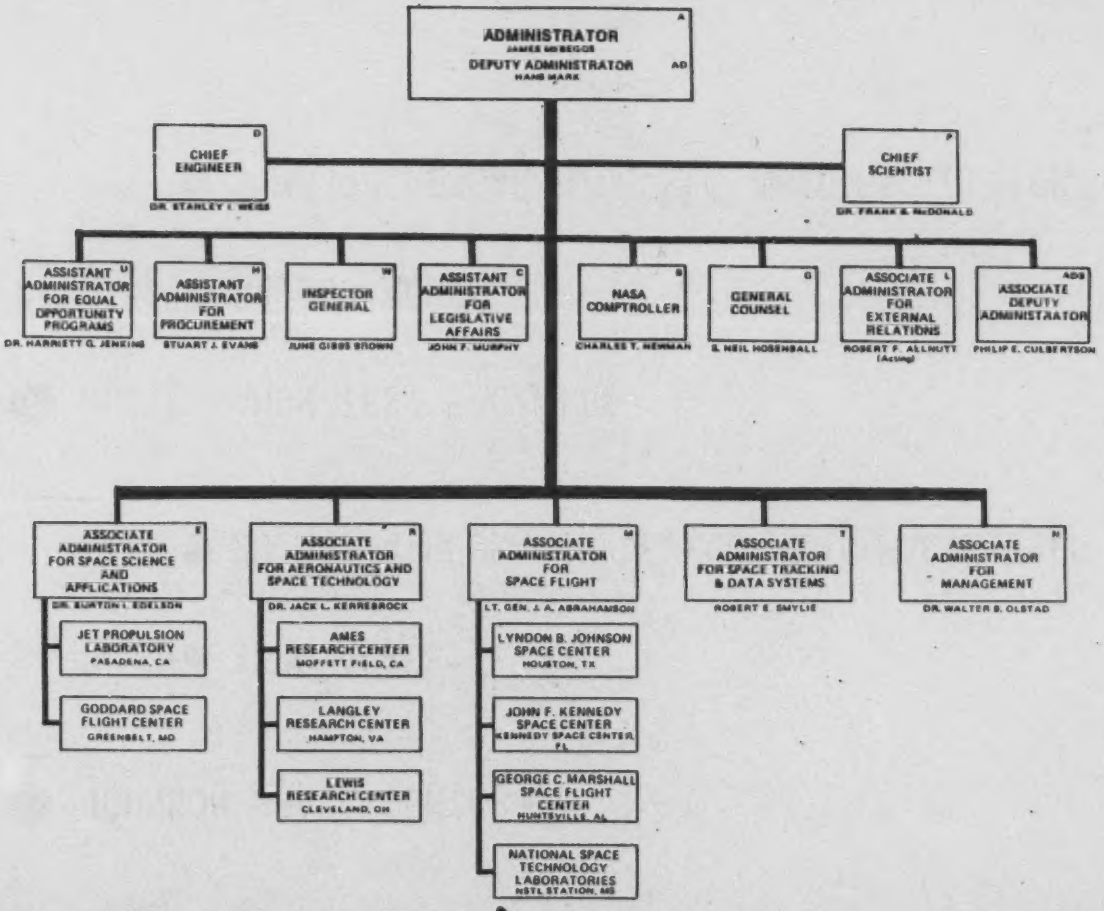
[Exhibits A-1 thru A-16 of Mr. Griffin's oral presentation follow:]

WELCOME AND OVERVIEW OF CENTER

MR. GRIFFIN



- JOHNSON SPACE CENTER
  - 1620 ACRES
  - 20 MAJOR RESEARCH/DEVELOPMENT FACILITIES
- WHITE SANDS TEST FACILITY
  - 54,080 ACRES
  - 5 MAJOR RESEARCH/DEVELOPMENT FACILITIES


ADMINISTRATOR
JAMES M. BEGGS
A
DEPUTY ADMINISTRATOR
HANS MARK
AD
CHIEF ENGINEER
D
DR. STANLEY I. WEISS
CHIEF SCIENTIST
P
DR. FRANK B. McDONALD
ASSISTANT ADMINISTRATOR FOR EQUAL OPPORTUNITY PROGRAMS
U
DR. HARRIETT G. JENKINS
ASSISTANT ADMINISTRATOR FOR PROCUREMENT
H
STUART J. EVANS
INSPECTOR GENERAL
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JUNE GIBBS BROWN
ASSISTANT ADMINISTRATOR FOR LEGISLATIVE AFFAIRS
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NASA COMPTROLLER
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GENERAL COUNSEL
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S. NEIL HOSENBALL
ASSOCIATE ADMINISTRATOR FOR EXTERNAL RELATIONS
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(Acting)
ASSOCIATE DEPUTY ADMINISTRATOR
ADS
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ASSOCIATE ADMINISTRATOR FOR AERONAUTICS AND SPACE TECHNOLOGY
R
DR. JACK L. KERREBROCK
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GEORGE C. MARSHALL SPACE FLIGHT CENTER
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NSTL STATION, MS
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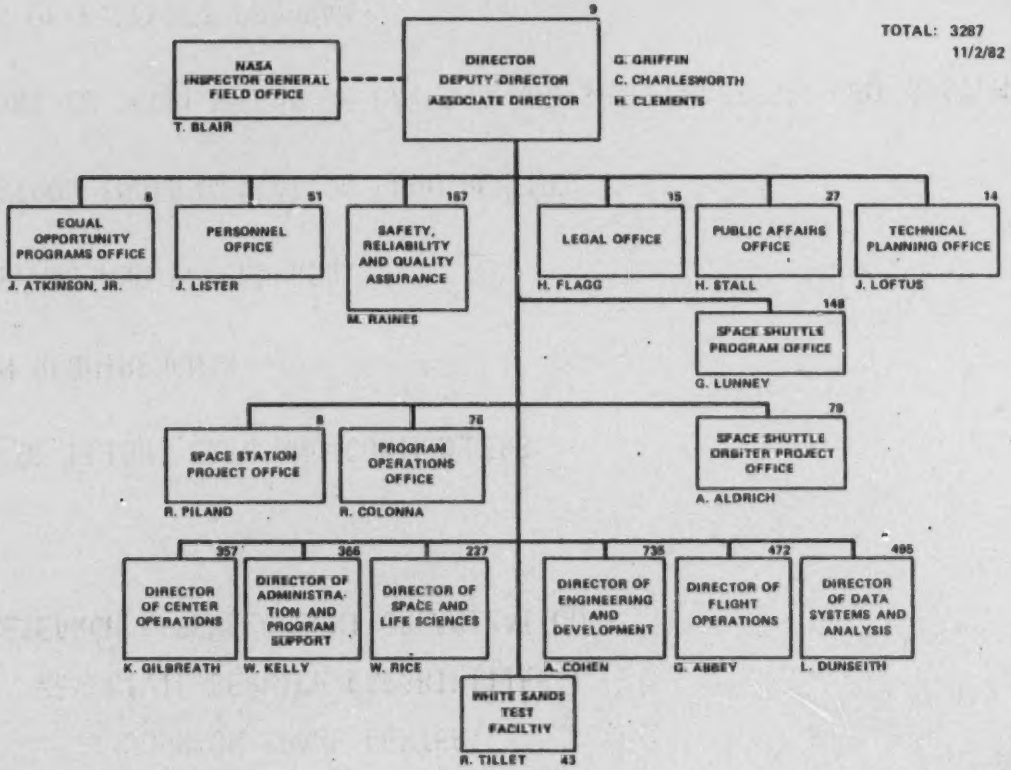
T
ROBERT E. SMYLIE
ASSOCIATE ADMINISTRATOR FOR MANAGEMENT
N
DR. WALTER B. OLSTAD

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS



JOHNSON SPACE CENTER

KEY CIVIL SERVICE CAPABILITIES

RESEARCH & DEVELOPMENT ORGANIZATIONS

FLIGHT OPERATIONS

- PROVIDING AND TRAINING OF FLIGHT CREW AND CONTROLLERS
- ESTABLISHING SIMULATION REQUIREMENTS
- DEVELOPMENT OF FLIGHT PLANS AND PROCEDURES
- ESTABLISHING FLIGHT CONTROL INSTRUMENTATION REQUIREMENTS
- OPERATIONAL CONTRIBUTIONS TO DEVELOPMENT OF PAYLOAD AND SPACECRAFT SUPPORT SYSTEMS
- DIRECTION AND OPERATION OF AIRCRAFT PROGRAM
- OPERATIONAL PLANNING AND CONDUCTION OF EARTH RESOURCES MISSIONS

ENGINEERING AND DEVELOPMENT

- ENGINEERING DEVELOPMENT AND SUPPORT FOR R&D PROGRAMS IN TECHNICAL AREAS OF: GUIDANCE, NAVIGATION, AND ATTITUDE CONTROL; TELEMETRY AND COMMUNICATIONS; MECHANICAL AND ELECTRICAL POWER GENERATION AND DISTRIBUTION; ALL ELECTRONIC SYSTEMS INCLUDING DATA MANAGEMENT, DISPLAY, INSTRUMENTATION, AND CHECKOUT; STRUCTURES AND MATERIALS; THERMAL PROTECTION AND CONTROL; MECHANICAL SYSTEMS; PROPULSION; PYROTECHNICS; LIFE SUPPORT; SPACESUITS; CREW PROVISIONS; HABITABILITY; AERODYNAMICS AND SYSTEMS ENGINEERING.

DATA SYSTEMS AND ANALYSES

- o DESIGN, IMPLEMENTATION, OPERATION, AND MAINTENANCE OF GROUND-BASED SYSTEMS
- o PROCESSING EARTH RESOURCES DATA
- o DEVELOPMENT OF MISSION PROFILES, TRAJECTORIES, AND CONSUMABLES ANALYSIS
- o OPERATION OF CENTRAL COMPUTING FACILITY
- o DEVELOPMENT AND IMPLEMENTATION OF FLIGHT COMPUTER HARDWARE

WHITE SANDS TEST FACILITY

- o TESTING OF SPACECRAFT PROPULSION AND POWER SYSTEMS
- o SCREENING AND CERTIFICATION TESTING OF MATERIALS
- o ENVIRONMENTAL TESTING OF EQUIPMENT
- o HIGHLY SOPHISTICATED CLEANING
- o RANGE COORDINATOR FOR AGENCY AT MISSILE RANGE

SPACE AND LIFE SCIENCES

- o PLANNING AND CONDUCTING PROGRAMS IN LIFE SCIENCES, MEDICAL RESEARCH, SCIENCE EXPERIMENT DEVELOPMENT, SCIENCE PAYLOAD MANAGEMENT, LUNAR AND PLANETARY SCIENCE, EARTH RESOURCES, AND SPACE SCIENCES

SHUTTLE PROGRAM OFFICE

- o OVERALL SYSTEMS MANAGEMENT AND INTEGRATION OF ALL SHUTTLE PROGRAM ELEMENTS IN RESPONSE TO HEADQUARTERS DIRECTION
- o MANAGEMENT OF THE LEAD CENTER INSTITUTIONAL FUNCTIONS AS RELATED TO SHUTTLE PROGRAM

ORBITER PROJECT OFFICE

- o OVERALL MANAGEMENT OF THE DESIGN, DEVELOPMENT, TEST, AND PRODUCTION OF THE ORBITER

PROGRAM OPERATIONS

- o CONFIGURATION MANAGEMENT
- o ENGINEERING EVALUATION OF GROUND TEST, SYSTEMS CHECKOUT AND FLIGHT TEST
- o SYSTEMS ENGINEERING AND PAYLOAD INTEGRATION
- o DEVELOP TEST PLANS AND CRITERIA

SAFETY, RELIABILITY, AND QUALITY ASSURANCE

- o DEVELOPMENT AND IMPLEMENTATION OF THE OVERALL SAFETY, RELIABILITY, AND QUALITY ASSURANCE ACTIVITIES FOR JSC, EXCEPT FOR AVIATION SAFETY

SUPPORT ORGANIZATIONS

ADMINISTRATION & PROGRAM SUPPORT

- PROVIDES THE BUSINESS MANAGEMENT FUNCTIONS OF PROCUREMENT, PROGRAM CONTROL, ACCOUNTING, MANAGEMENT ANALYSIS, AND UNIVERSITY PROGRAMS

CENTER OPERATIONS

- PROVIDES AND ATTENDS TO THE TOTAL REQUIREMENTS OF THE JSC PHYSICAL PLANT
- PROVIDES BASIC INSTITUTIONAL FUNCTIONS SUCH AS PHOTO PROCESSING, LOGISTICS, AND TECHNICAL SHOP SERVICES

DIRECTOR AND STAFF OFFICES

- PROVIDES THE MANAGEMENT AND FUNCTIONAL SUPPORT IN AREAS OF: EQUAL OPPORTUNITIES PROGRAMS, PERSONNEL, PATENT, LEGAL, PUBLIC AFFAIRS, AND TECHNICAL PLANNING

JOHNSON SPACE CENTER
BUDGET PLAN
(THOUSANDS OF DOLLARS)

	FY 1981	FY 1982	FY 1983
RESEARCH AND DEVELOPMENT PROGRAMS	1,523,609	1,616,217	1,613,744
SPACE TRANSPORTATION	1,464,500	1,566,900	1,554,620
SPACE SHUTTLE	1,298,700	1,328,900	1,034,400
SPACE FLIGHT OPERATIONS	165,800	238,000	520,220
SPACE SCIENCE	24,502	26,005	34,224
PHYSICS & ASTRONOMY	2,001	1,485	4,360
PLANETARY EXPLORATION	8,397	11,400	8,900
LIFE SCIENCE	14,104	13,120	20,964
SPACE AND TERRESTRIAL	26,667	15,162	15,050
SPACE APPLICATIONS	26,667	15,062	15,050
TECHNOLOGY UTILIZATION		100	
AERONAUTICS & SPACE TECHNOLOGY	7,940	8,150	9,850
AERONAUTICAL RESEARCH & TECHNOLOGY	190	150	150
SPACE RESEARCH & TECHNOLOGY	7,600	8,000	9,700
ENERGY TECHNOLOGY	150		
RESEARCH AND PROGRAM MANAGEMENT	176,051	186,635	192,396
PERSONNEL AND RELATED COST	133,136	137,991	137,479
TRAVEL	3,477	4,709	4,709
FACILITY SERVICES	20,051	23,158	27,093
TECHNICAL SERVICES	7,005	6,052	6,492
MANAGEMENT AND OPERATIONS	12,382	14,725	16,623
CONSTRUCTION OF FACILITIES	2,700	4,500	3,500
TOTAL	1,702,360	1,807,352	1,809,640

Dr. LUNNEY. Mr. Chairman, members of the subcommittee, ladies and gentlemen, it's nice to be here this morning. I thought I would try to show you some things which are an attempt to describe the program, mostly in pictures. I fallen victim in occasional cases here; these charts do our words, and perhaps some of our little jargoning, so I'll try to correct those as we go along.

[Exhibit B-1.]

[Exhibit B-2.]

Dr. LUNNEY. This is STS-5 going to the pad. First, let me go through the outline for you. I'll give you an overview and a little description of the system, program organization, benefits to the Nation—which is probably misnamed, but I'll try to give you some flavor for the scope of the program—a typical shuttle mission and a few photos from flight 5—what we learned in the last five fligths, what was good and what was bad, how we're going on flight 6, what we're doing for the future; I'll just mention the relationship that we have with the Air Force, because it's and important parameter in our work and it's fairly pervasive in a lot of areas as to the things we do together; and give you some idea, at least, of what my personal version of the future is in respect to the future for the shuttle.

[Exhibit B-3.]

I suppose that these would be historical, but we see that the shuttle really is a descendant of everything that we've done in powered flight in the country, starting here in North Carolina. As you go on through all the airplanes that we built—Jerry showed us a small number of people who are involved aeronautics, but the technology that we put in this orbiter is going to see its way and already has seen its way back to the commercial airline industry in this country

We started the manned space flight program here in the sixties, with the flights in the sixties, culminated by Apollo. We did Slylab for about a year—almost a year. We did one mission with the Russians, and of course, now we are flying the space shuttle.

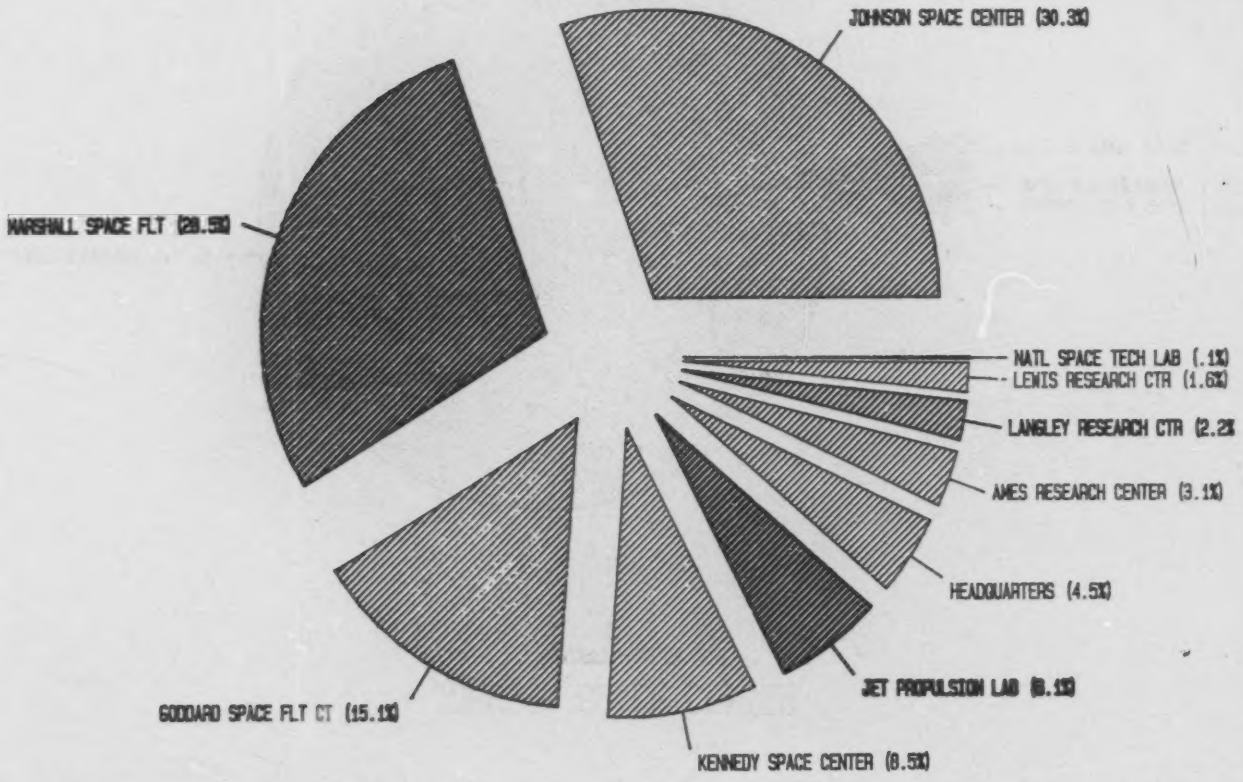
[Exhibit B-4.]

The manned space flight program looks like this, and I'll come back and connect this on the next chart with some other activities that the country has had going on. But we started with the Mercury program—which, by the way, the spacecraft here weighed about 2,000 pounds, and on the space shuttle we landed about 200,000 pounds; so in gross terms, the weight of the vehicle return has grown by a factor of about 100. Gemini was a spacecraft by itself, and it sometimes rendezvoused and maneuvered with an Agena stage. All this work was a precursor for the work of going to the Moon in the Apollo program.

By the way, as an aside of sorts, I was up at the New Mexico Space Hall of Fame, and the occasion was to honor some Gemini astronauts, and at the time that Jerry and Cliff and I were involved in the Gemini program, we were all 25-Year-old hotrodders working in the Control Center, and we just had fun doing it. But I don't think until we got a little older that I appreciated how the experience of Gemini rolled us through Apollo. The people, the operational teams that came out of Gemini, both the astronaut, the flight crews, and the ground crews—when they finished up with

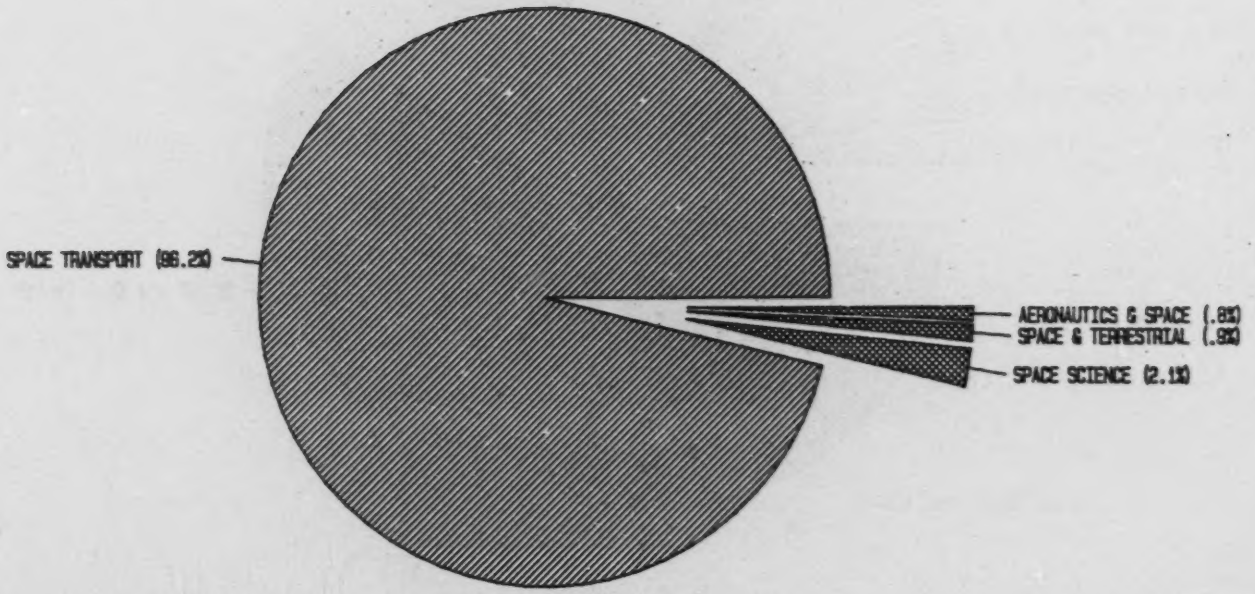
NATIONAL AERONAUTICS AND SPACE ADM

R & D BUDGET PLANS BY CENTER FY 1983


JOHNSON SPACE CENTER (30.3%)
MARSHALL SPACE FLT (20.5%)
NATL SPACE TECH LAB (.1%)
LEWIS RESEARCH CTR (1.6%)
LANGLEY RESEARCH CTR (2.2%
AMES RESEARCH CENTER (3.1%)
HEADQUARTERS (4.5%)
JET PROPULSION LAB (8.1%)
KENNEDY SPACE CENTER (8.5%)
GODDARD SPACE FLT CT (15.1%)

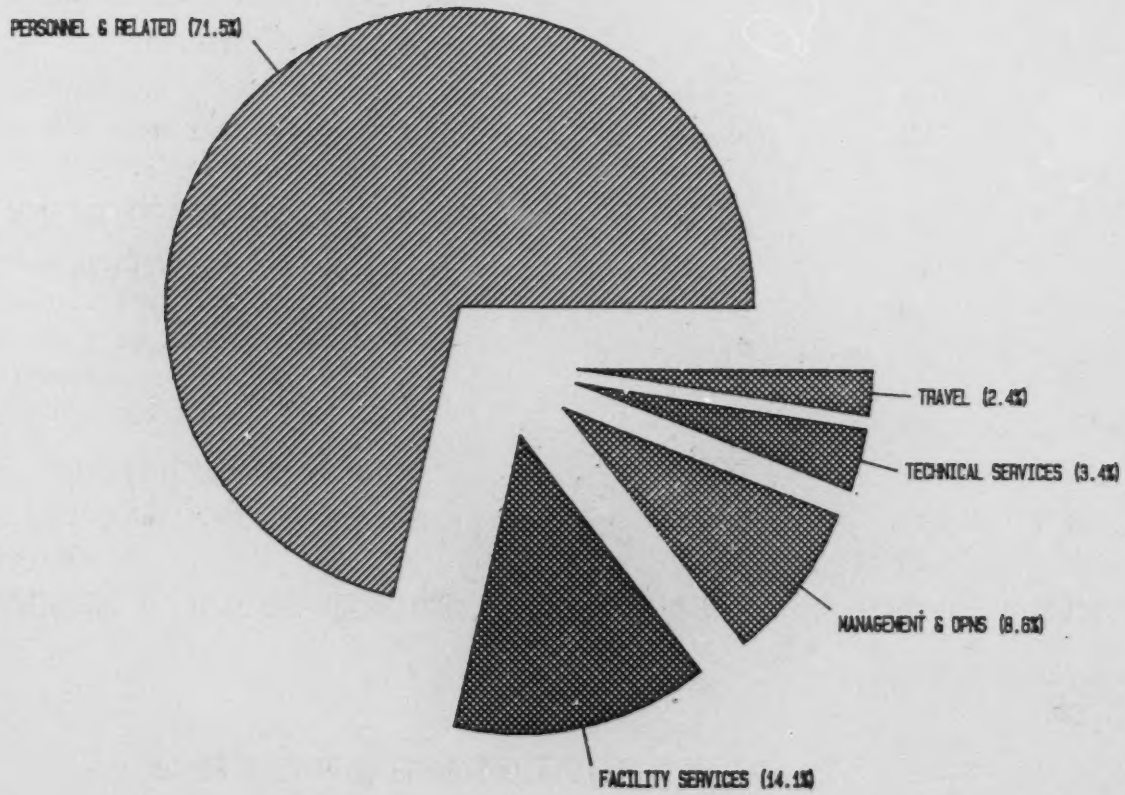
JOHNSON SPACE CENTER

R & D BUDGET PLAN FY 1983



JOHNSON SPACE CENTER

R & PM BUDGET PLAN FY 1983



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DISTRIBUTION OF PERMANENT POSITIONS BY PROGRAM

	1981	1982	1983 ESTIMATE
SPACE TRANSPORTATION SYSTEMS AND OPERATIONS	2,473	2,503	2,450
Space Shuttle	1,943	1,582	1,000
Space Flight Operations	530	921	1,450
SPACE SCIENCE AND APPLICATIONS	332	274	271
Planetary Exploration	38	38	38
Life Sciences	110	113	114
Physics and Astronomy	14	15	15
Space Applications	166	104	100
Technology Utilization	4	4	4
AERONAUTICS AND SPACE TECHNOLOGY	31	30	30
Aeronautical Research and Technology	5	5	5
Space Research and Technology	26	25	25
Energy Technology	-	-	-
SUBTOTAL	2,836	2,807	2,751
CENTER MANAGEMENT AND OPERATIONS SUPPORT POSITIONS	544	539	536
TOTAL	3,380	3,346	3,287

DISTRIBUTION OF JSC

POSITIONS

ADMINISTRATIVE PROFESSIONALS	459
SCIENTISTS AND ENGINEERS	2,092
CLERICALS	458
TECHNICIANS	278
TOTAL	3,287

AVERAGE AGE OF WORKFORCE

YEAR	AGENCY	JSC
1982	-	43.6
1981	43.8	43.2
1980	43.5	42.5
1979	44.3	43.4
1978	44.2	43.2
1977	43.9	42.9
1976	43.3	42.2
1975	43.0	41.6
1970	41.0	38.2
1968	40.0	36.0

the ten or so flights of Gemini, we rolled through that program in a very short period of time. We went to the Moon on the second manned flight and we landed on the fifth manned flight in that program. So the experience builds and it goes very rapidly, and it provides confidence in hardware and confidence in people, and it's what the program, as Jerry described, is still rolling on.

Sky lab, you know what we did there, and I'll talk most of the time about the space shuttle.

Congressman LUJAN. For those of us who are civilians and new to this program, am I correct in that Mercury was manned? Was that the John Glenn flight?

Dr. LUNNEY. That was the first manned orbital flight.

Congressman LUJAN. I connect Gemini with twins, two in a craft. Apollo is three or more?

Dr. LUNNEY. Right. Mercury was the first step to do it. Somewhere in the middle of that program, we decided to go to the Moon and somebody else wisely decided that a good intermediate step whould be the two-man Gemini twin program to build confidence in a lot of things that we hadn't done yet with Mercury.

Congressman LUJAN. How many Mercury flights were there?

Dr. LUNNEY. The manned ones were 6, 7, 8, and 9; four manned ones to orbit. And then there was 3, 4—Al Shepherd and Gus Grissom's flights, the short ones, suborbital hops. And then 10 manned Gemini's.

[Exhibit B-5.]

The other thing that has characterized space activity in our country within NASA and also, I guess, you could say within the Department of Defense is that there has been a rather strong line of demarcation between what I would call the manned programs and then the unmanned programs. The manned programs were involved in however you would want to characterize the Mercury, Gemini, and Apollo—kind of an exploration first if you will, while the satellites were—unmanned satellites were involved in communication satellites, of course, an industry unto itself in our country, scientific satellites for measuring the phenomena, both on the Earth and outside, and, of course, the Department of Defense satellites. And these two familes grew up separately—relatively separately and relatively loosely connected; very little connection between the two programs.

Now we see that we've tried to take the best that we can find here and put it into the space shuttle and the orbiter, and then that performs as initially a delivery system to bring these satellites on orbit; but as we move into the future, it will become more than a delivery system when we become a reservicer and an aggregater of these things, and it enables us to build larger things; and it's not size for the sake of size, but as we look into the future, we see that by being able to do something twice as big, you can all of a sudden enable things to happen that you couldn't have done at half the weight before.

Congressman LUJAN. When you launch the orbiter, that just goes into low Earth orbit; but it's my understanding that often we launch satellites into orbits as high as 22,000 feet.

Dr. LUNNEY. Right.

Congressman LUJAN. How are you going to launch them off the shuttle? Are you going to have a rocket there?

Dr. LUNNEY. We have rockets which mount in the cargo bay, and we have some pictures of the two that we developed that we flew on flight 5.

Congressman LUJAN. Well, they're certainly not like the ones we see at the cape.

Dr. LUNNEY. Maybe you're getting the idea that you fire the rockets off the orbiter. You don't. It's separated and it goes—and then you fire an engine and it goes, and you'll see a couple of versions of the rockets and the size of them in the cargo bay, and it will give you a feeling of what these are like.

[Exhibit B-6.]

This, of course, is what an orbiter looks like, and we've set about building four of these as a fleet to provide this transportation for the country and the free world as it chooses to use the space shuttle.

[Exhibit B-7.]

Appropriate to your question, the way we use the shuttle is by carrying things up in the cargo bay. You know about the tank, which, by the way, is now brown and preferably will be. We saved about 600 pound of weight and some amount of money, but the real reason was weight; so we did not paint it.

Chairman VOLKMER. Can I ask a question about that now, or would you rather wait until you've finished your presentation?

Dr. LUNNEY. Go ahead, please.

Chairman VOLKMER. We've got a lightweight tank now.

Dr. LUNNEY. Yes, sir.

Chairman VOLKMER. Do you see any problems at all in the utilization of that lightweight tank as far as structurally being able to withstand the pressure?

Dr. LUNNEY. No, sir, not at all. We've been very careful about that. It's been through a test program on it; it's been through a loading program at the cape. We've used it now in terms of loading the fuel onboard the two flight readiness firings we've had at the cape, all the results are very positive. As a matter of fact, it's some lighter than we originally set as the target goal.

The solid rocket boosters are this size, very larger; but the ones we use in the cargo bay, for example, to go on to geosynchronous might be this big in the same scale, or they might be as small as this satellite right here where this frame would sit across the cargo bay and the rocket would just pop out when we release it, and it ignites about 45 minutes later.

Congressman LUJAN. Why do you make such a big deal about that tank being brown? What's the significance?

Dr. LUNNEY. We originally painted the first couple of tanks white, and it was all white.

Congressman LUJAN. It just looked pretty.

Dr. LUNNEY. But it's the same thing.

Congressman ANDREWS. Well, actually it's a burnt orange.

[Exhibit B-8.]

Dr. LUNNEY. This is a planned set of orbiter deliveries. We've seen Columbia five times and Challenger is on the pad today. Discovery comes this fall in September, and Atlantis behind it next

year in December. You will hear today about the status of the orbiter production; in a word, it's gone very well.

Chairman VOLKMER. At this time, can we ask also the differences between the Columbia and the Atlantis?

Dr. LUNNEY. Yes. If I could characterize it briefly for you, right today, Columbia is probably different from all three of these. All three of these are much more alike than Columbia. Some of it is in the outside thermal protection that we have on the top side. We've gone to blankets rather than a lot of tiles. But inside, we have a number of changes to the cockpit, which you might call more operational cockpit configuration. We've added some things late in the program. And the problem was that Columbia was so far along in production that we couldn't put all our good ideas in it; so the following three birds, the three orbiters had some more equipment and some more capability than does exist today in Columbia. However, we do have a plan to retrofit Columbia in 1985. There's some amount of retrofit going on now, but a major retrofit in 1985, so that as far as possible we can make the four of them look and act alike. They will always have some difference in structural weight. One of the other major things we did with the later orbiters was to go back in and shave out weight in a variety of places to the tune of—let me see. Columbia and Challenger are what?—4,000 pounds different in dry weight. So changes of that type, Tom can talk more about that when he talks about the orbiter production.

[Exhibit B-9.]

The facilities at KSC—this is STS-5 going to the pad. In our jargon, this is the vertical assembly building. You'll hear it referred to as the VAB. We're using pad A. We have another pad that will be available in later 1986. We had two of these things, this crawler that we call MLP's, mobile launcher platforms. They were built to haul the Apollo rockets to the pad. We're using, by the way, the same pads that we used in Apollo, the same crawlers, the same vertical assembly building.

[Exhibit B-10.]

On this side of the building is the launch control center, and on the far side—here, there's a better view of it in the picture. This is the vertical assembly building; this is the launch control center. These two—you can call them low bays, but they're really pretty high—are the place where we bring the orbiter after it lands. We tow it over here and do whatever refurbishment is required, and then it is brought into this building where it is stacked, and I have some pictures to show you that stacking process in a minute.

This is the shuttle landing strip, of course. As a matter of fact, we have a 747 and an orbiter at the strip in the picture.

This is one of the mobile launcher platforms. There is a third one which is beginning to go under modification for availability in 1986, also. Those are the major facilities there. Pad B is over a little bit; you can't see it on either one of those pictures.

[Exhibit B-11.]

This is the construction reasonably recent at Vandenberg. Vandenberg is surprisingly a different place. The launchsite at Kennedy is sort of flat and we think of big wide roads, and once you can control the water and the alligators, it's relatively easy to get around it.

Vandenberg is characterized by a lot of elevation changes, and there really is not a large network of roads like you see when you travel around the Kennedy Space Center. The pad is down at the south end of Vandenberg. There are other pads further up north and was original—I don't know what it was built for originally, but it was being modified for the Air Force Gemini MOL program or the manned orbiting laboratory program, in the 1960's when that program was canceled.

The pad itself is right here, and one of the major differences at Vandenberg is that the shuttle itself is stacked up on the pad. At Kennedy, we stack these on the crawlers, and if you want to think of it as a big hanger and then we bring it out to the pad to launch it. But at Vandenberg you stack on the pad, and then you put the tank in and then you put the orbiter in, and then you open the bay doors and put the cargo in.

The cargo or the payloads that fly in it are processed down here in this building. We put the rockets together and then the tank is brought in and swung up, and then the oribiter is swung up. And by the way, these facilities are both cranes and assembly protective buildings—protective enclosures, because we found that when we were doing this hoisting operation and lifting operation, just the wind itself on these very large surfaces gets to be a problem in controlling it. And when we're stacking these facilities are brought in and form almost an enclosure around the vehicle so it is not subject to the elements, not subject to the wind, and it's easier to stack.

Congressman LUJAN. You stack them in the building and move them?

Dr. LUNNEY. Well, the building is sort of like—it's on rails and it moves up and protects it, and then it moves back for launch.

Mr. GRIFFIN. You might give us a sense on why Vandenberg and Kennedy; why two launchsites.

Dr. LUNNEY. For several reasons, I suppose. The site at Kennedy is, of course, on the eastern coast of the United States, and we launch with the rotation of the Earth; it takes full advantage of that—as close as we can get to the equator. In the early days, the rockets went out over the water and any problem would end up in the drink. For the Department of Defense—primarily the Departmernt of Defense in the sixties, there was a high degree of interest in having polar capability which allows a satellite to go around the Earth, and, in effect, the Sun stays at the same angle; so it's convenient for weather satellites, reconnaissance satellites, or other things of that type, because you can see the whole Earth as you go over it rather than the part that's limited to whatever you launch out of Cape Kennedy with. You see the whole Earth, and Sun angles are usually——

Chairman VOLKMER. A polar orbit travels a north-south rotation?

Dr. LUNNEY. The orbit goes over the poles; so as the Earth rotates, you just see everything down there sooner or later in the course of a day as best as you can look.

That is also convenient for weather satellites and for NASA's Earth resources satellites. The Landsat satellites also use the polar orbit because they want to see the whole Earth, and they also eliminate one of the difficulities in processing the data by having ap-

proximately the same Sun angle. It turns out the scanners and the sensors that you use in that kind of system are sensitive to Sun angle, and you can arrange the orbit so the Sun angle stays the same, and you're dealing with that as a constant and not another variable that has to be accounted for in understanding what the data is trying to tell you.

Plus the Vandenberg thing in another sense, this is a major part of the Air Force activity in this program and, in effect, it is a method or an opportunity for the Air Force to become involved in the manned space flight business by this relationship with the Space Shuttle program.

[Exhibit B-12.]

Jerry's talked about these centers and you know about Headquarters and Langley in Virginia; Marshall's in Alabama; Kennedy, and; the technology laboratories are in the corner of Mississippi. We build a tank right here in Michoud right outside of New Orleans; that is, we put the tank together. It's built—pieces of it are built all over the country, but then it's assembled at an old Chrysler tank plant that was used in the war right outside of New Orleans. Johnson Space Center is where you are; White Sands test facility—it doesn't look like it's been spotted in the right place. I wouldn't have put it that high.

Congressman LUJAN. Or that west.

Dr. LUNNEY. Downey is the home plant for Rockwell International where various parts of the orbiter are put together; Canoga Park is where the engines are built; Santa Susana is where—all these being right in the Los Angeles area where we do some engine testing; Vandenberg launch base being right here; Ames; the Dryden Research Center out at Edwards where we land; and then up in that area at Palmdale is where we assemble the orbiter, and you'll see some pictures that Tom will show you. The major assemblies of the orbiter are brought in from all over the country and they are put together as an air frame at Palmdale.

[Exhibit B-13.]

Organization. Wiring diagrams. I suppose we have to do this to you. Jerry described the—and I left one installation off. Jerry described three major centers—Marshall, Johnson, and Kennedy—and there is, of course, the NSTL, a test laboratory in St. Louis.

The difference is this chart is that what you might call the normal institutional lines are shown in blue where the director of the center, Jerry Griffin, is here, and I work for him as an employee of the center; and I also have another job. Arnie Aldrich in the Orbiter Project Office also works for Jerry at the center, although, as Jerry descirbed in a kind of a "breing the whole program together" way, the office that I am in interfaces and deals with the project offices at other centers. Marshall has had a long history of excellence in propulsion systems, and they build on contract with the industry the main engines of the solid rocket boosters, the external tank, and then, of course, they do their own systems engineering and tie some of that together. And I deal directly with people in that center and at the Kennedy Center, and I also deal, fo course, with the institutional managers and the people in Washington; and I suppose it's fair to say that you have to be here to fully appreciate how it works. But there are an awful lot of talent-

ed people, a lot of them work directly on the program, and some of them not directly on what you might call the program chain of commmand, but they are very active and operate on it, and the program has the advantage of their experience and their ideas as we go forward. Wire diagrams are hard to explain, but it works reasonably well and most of us are confortable with it.

Congressman ANDREWS. Before we move into something else, I would like to ask you a question and also maybe ask Jerry to comment. There is a current GAO report out that quotes a NASA memorandum that was dated in August of last year that suggests that the Johnson Space Center be moved to Kennedy, moved to Florida. I'm curious if you're aware of that NASA memorandum, and if you would care to comment on the memo, but also comment on the need or lack therein to consolidate the facilities in Florida.

Mr. GRIFFIN. Let me start and maybe Glynn can pick up. The memo actually addressed operation's aspects of the space shuttle program and posed the question: Could certain operational capacities currently being performed at Johnson be moved to Florida. And there was a study carried out—and I've forgotten what year that was in—and that was looked at, and it proved to be, of course, extremely expensive to do that, because of the facilitization that we had done here over the years would have to be replicated in some sense at the Kennedy Space Center to do that. So the cost was large. Obviously, you could do anything that one wanted to do. You could move it all to St. Louis, if we decided to to that, or to White Sands. But the cost is a very prohibitive thing to consider.

There are still—and I frankly don't know all that may be going on outside of JSC, but I still think there are people that are thinking that there are at least pieces, maybe not all of it, but maybe pieces could be moved to Kennedy or to Vandenberg or somewhere else. I don't think you're going to see—my personal opinion is: you won't see anything happen in the very near future, and you may—to the degree of what happens as the system matures, largely depends on how well the system operates as we get the fleet completely assembled and get our pipelines and our logistics lines all established. A lot will depend on how, I believe, that hardware performs over a fair length of time. It will probably steer us to do some things that are logical; and if they're not logical, we won't do them.

It's not a very crisp answer, but I think what we'll do is we'll do what's right for the long haul, and we won't force it to happen just as a thing we decide to do. There will be some changes, obviously, in the next 5 years, next 10 years for sure, on how this system operates, and we will have to look for the—we want to do what's best for the country in terms of cost effectiveness, and we want to do it in a way that makes our job easy to manage in terms of—this is a complex system to manage, so we'll want to do it as simply as we can as the system matures.

Congressman LUJAN. Wouldn't that all depend on how the whole transportation system is managed in the future, whether it's government or a corporation?

Mr. GRIFFIN. That could enter into it.

Congressman ANDREWS. The budgetary dollars in this year's budget for the Johnson Center, $85 million; do you see that as fi-

nancing of interim facilities as is suggested in that GAO report or do you see it as dollars to be spent in long-term programs over the next 10 or 20 years?

Mr. GRIFFIN. I'm not sure what the $85 million——

Chairman VOLKMER. Or 65 or—how much do you have—for 1984, you've all got about 3.5. In 1983, didn't you have——

Mr. GRIFFIN. The entire Agency is up, and most of that is C of F or construction of facility money that falls into what I would call minor rehab and mod money. It's a compilation of a lot of smaller pieces, which incidentally the center has fought for very hard, the entire institution's agent, and although we're very fortunate here at Johnson—we're only 20 years old—some of the centers are literally falling apart, and most of that money is in relatively small rehab and modification. We have not started here at Johnson doing any major new facility, nor is there any major new facilities at any of the space training station, centers. Mike, I don't know of any.

Mr. WEEKS. In the 1984 budget, we have raised from the $100 million that's been typical to a $150, and one of the big pieces in the 1984 budget is the third mobile launcher platform, and as well as finishing up with pad B, which comes on line, as Glynn Lunney said, in 1986.

Chairman VOLKMER. But buildings and equipment like that, laboratories——

Mr. GRIFFIN. Brick and mortar—the biggest thing that the Agency is going after, I think, in the 1984 budget is the NAS, the numerical aerodynamic simulation at Ames, which is not space related directly.

Mr. BRANSCOME. I believe the $85 million Mr. Andrews was referring to was for the upgrading of Misssion Control Center, and that's with reference to the GAO report which was released in December 1982.

Dr. LUNNEY. That money is spread over several years, and that money had to do with building the control center so that we could operate several missions at a time, even though they may not be flying; we could fly one and train for another. In the past, the building was configured as kind of a serial place, where you flew one thing, it was over, you stopped, and then you revved back up again.

Chairman VOLKMER. Also data control for military flights, too.

Mr. GRIFFIN. Yes; and those are Mr. Andrews, spread out over a number of years.

[Exhibit B–14.]

[Exhibit B–15.]

Dr. LUNNEY. Jerry mentioned to you the lead center idea. That was a controversial, perhaps, and difficult thing to decide, because as it implies, it involves some of the sister centers surrendering some authority, in a sense; so it was a little difficult. But it was believed at the time and I, in retrospect, think correctly so that integrating of this thing in a technical way and in a programmatic way was a job that would take a sustained activity by a number of people. And in the past program, in Appollo, that was tended to be done at headquarters, which was augmented by a large contractor's staff. I can't remember if it was 5, 6 or 700 Bellcom people which it took to do that kind of job that was done on Appollo. So what we

did in the Shuttle was to move that down one notch, and this program office was located at JSC, and the man that was in the job before me, Bob Thompson, whose name you might have heard, served in that job until after STS-1 and kept this whole team together and kept it on track and got there on time.

We, of course, plan the work is what that says. And we have a program office and mostly I interface with Government people. I don't have necessarily contractors in the industry working through the program office—the shuttle program office, but rather I deal with, for example, Tom Moser and Arnie Aldrich downstairs on the orbiter, and they hold the contracts with Rockwell. So our function is more internal to the Government, although we do some amount of contracting work; but mostly it's keeping the Government team, keeping the agenda before them, and keeping them all integrated and working together, which, by the way, is not very difficult because the attitude of the various Government project officials in the program is really terrific. They're very supportive of keeping the whole thing working, and it is not a bureaucratic problem of any kind to pull that off.

We did, of course, in that process, in that integrating, if you want to call it that, the various project elements of the Shuttle system together and we also integrate them with the various launch and landing sites, ala Kennedy and Vandenberg. In that sense, the project managers are in a form of a line relationship to me, but it's not what you might call a typical line relationship; but it works that way reasonably well.

A lot of documentation. We try to reduce travel with telecon's, and we have a lot of participation with the Air Force at various levels.

[Exhibit B-16.]

Benefits to the Nation. I'll just mention a few of these things and perhaps it's not quite correctly labeled, but it will give you some idea of the scope for the program.

[Exhibit B-17.]

In science and applications, we have a variety of capabilities now available to us. We have this cargo bay in which we can put all kinds of payloads which can either be satellities that can be dropped off, or we can conduct experimental activities; and I want to tell you about one we did in the early flight series.

[Exhibit B-18.]

The shuttle, I can show you what it looks like. This simulates a set of instruments similar to the instruments that we flew on STS-3. This is a package of instruments that we flew on STS-2 These instruments on STS-3 were basically outward looking, astronomy and solar kinds of instruments. On the STS-2, we flew a pallet, and you can see the frame of it here which just follows the circular outline of the cargo bay. And these instruments were all aimed at looking at the Earth. This is a radar system that we used to look at the Earth's surface. It turns out I'm starting to see some surprising things come out in the paper, the results of people looking at the data from that radar system. This is the back end of the orbiter. You've heard the expression OMS PODS a couple of times today. OMS for orbital maneuvering system, and PODS for pods, because we don't know what else to call them. They look like a little pod, a

bubble on the back end right below the tail, one on each side. The commercial here is on the remote manipulator system which is a long arm with all of the same joints you have in your own arms starting at the shoulder, and it rides up on the port side of the orbiter inside the cargo bay, at the bay's doors, and we open the doors and we are able to maneuver that around and see a couple of television cameras stationed on it.

[Exhibit B-19.]

This is some more of the kind of things we'll be able to do in the future. Spacelab 1, which is scheduled to be flown this September, a cutaway view of what you might see—where you might see people in there is a pressurized container which has a set of racks almost like a laboratory where you can put in different activities, was built by the Europeans on European money. They probably spent $800 or $900 million equivalent to American money building the first one, and we are in the process of buying a second one that when I was in Washington, about $200 million for the second one. But it constitutes a laboratory in which you could put instruments and a laboratory from which you can put other kinds of instruments outside and control from inside. And the theory is that you can create a laboratory complex of instruments offlying from the space shuttle itself and then come the time when the flight is to be flown, this equipment almost as a total complement is installed in what I refer to as the low hangers down there. It's installed and then the orbiter is taken into the vertical assembly building and is stacked with this kind of equipment already installed in it.

[Exhibit B-20.]

This is a sketch of the space telescope which NASA plans to fly; 1985 late was the last I heard, but somewhere in that time frame, which is designed to look out into the universe as far as we human beings are able to build machines to look.

Chairman VOLKMER. If we can stop right now to get back to an earlier question. As far as the space telescope and the radar mapper knows, could you just explain how that will work as far as the use of the boom?

Dr. LUNNEY. Yes. The Centaur stage does not use the remote manipulator boom. I have a picture later on which shows you after it's been ejected, but it rides in the cargo bay—the cargo bay will be like this—and it will rise on a cradle in here, and then when we want to deploy it, it will be erected and then it will be locked place; and then after the appropriate checks, we will separate it with a pyrotechnique device and springs mounted on the back end push it out very slowly but sufficiently to separate it from the orbiter. And then the orbiter goes through a series of maneuvers to maneuver away from it, and in general, about half a revolution or 45 minutes later, the engines are ignited and it's on its way.

Chairman VOLKMER. Will the engines be ignited from down here or from up there?

Dr. LUNNEY. An automatic program on board.

Chairman VOLKMER. Within itself, then?

Dr. LUNNEY. Right. And the way to look at that, in a manner of speaking, is that the orbiter becomes the mobile launch platform and the pad for these rockets and satellites that we'll be deploying from it, and they'll set up the attitude, they will participate in the

checkout, they can perform a number of backup things to be sure that the vehicle's ready to go, and then it's on its way.

Mr. GRIFFIN. Again, one of the benefits is that if it doesn't check out properly, we can bring it back down and bring it home and fix it.

Chairman VOLKMER. Centaur has engines then instead of rockets?

Dr. LUNNEY. It is a rocket engine that is, of course, tied to a great big set of tanks for hydrogen and oxygen which are then the fuel for two engines that are in the back end of the Centaur stage.

The Centaur stage that we will use in the shuttle is a derivative of the one we're flying today on the Atlas Centaur and had been flying since the early 1960's. I think we're up to flight 50-some on Atlas Centaurs, and it's worked very, very well. It's got two smaller, of course, engines than we use; and the primary difference in the vehicle is that we've made some of the stages larger in diameter so as to take advantage of the shuttle volume which is bigger than we normaly have under the shroud that our present launch room rockets use to contain the satellites. The top of the present launch vehicle is fairly narrow by shuttle comparisons, probably 6 or 8 feet in some cases; in some cases, up to 9 or 10; and the shuttle cargo bay is 15 feet. So what we're able to do is go out in diameter and make bigger tanks, which changes the stage, or course, but fundamentally, it doesn't change it. The same teams are involved, the same valves, the same employment, et cetera, but the shape of the tank is different.

Chairman VOLKMER. There's no problems; that's what amazes me a little bit. You see no problems in placing, whether it's a telescope or anything else that you want to place in a certain orbit up there with the shuttle. Setting it up there into space in the right degree, aimed in the right direction and everything else; that's just perfect. You see no problems with that?

Dr. LUNNEY. No, sir.

Chairman VOLKMER. That is amazing to me.

Dr. LUNNEY. I say that, you know—20 years ago, you're talking to the guys that rendezvoused with other things up there, and we took our spacecraft and got exactly to the other thing. We landed—Jerry was a prime flight director on Apollo 12 when we landed next to the Ranger that had been on the Moon for I don't know how many years—5 or 6 years. It landed on the Moon close enough so people could walk to it. So we have a lot of confidence that we can do that, yes.

Chairman VOLKMER. Now, the PAM's that are presently being used, how do they operate?

Dr. LUNNEY. I'll show you some pictures in a minute, but they are upper stages which provide extra velocity for kick to the satellites on their way to the geosynchronous altitude of 22,000 miles which we talked about before.

[Exhibit B-21.]

There is another picture, I believe, that shows the two engines. This is a version of Galileo. This is the LOX tank in the back which we have just added a section to and made it longer, I believe; and this is the hydrogen tank, and you can see it kind of bubbles out. We've gone to a larger diameter. A typical Centaur stage on

the Atlas Centaur today would be no more of a diameter than that. It would be straight. But we've bubbled this thing out and have been able to put some more propellant into it and get some more performance, which allows you to build more sophisticated and heavier spacecraft or put more fuel in them to do more maneuvering when they get to where they're going. In the case of Galileo, it's the planet Jupiter.

[Exhibit B-22.]

We talked about this a couple of times, but it hasn't come through exactly. The important numbers on this chart are the number in the year. Back in 1965 and 1966, we flew five Gemini missions a year. In Apollo, the max rate we achived was four—this is almost five in a year. In 1983, we are planning to fly five shuttles, which is sort of the max rate we have done in the past. And then from then on, it goes up fairly dramatically out into the later eighties. Those of us who were here at the time felt that the crews and the teams were meeting themselves coming and going from the pad from each mission when we flew five flights a year. So we are quite challenged by putting together our act, if I might call it that, to fly 12, 15, 16, 18, 20 flights a year after we move out into the 1980's. It's a problem of production for us. It's learning how to produce these things without standing around hand tailoring every flight to the last inch. We're trying to find a way to plan them in a nominal way with margins to that kind of "off-the-shelf" flight software and techniques are going to work. We've already seen a marked improvement in, for instance, changes to the flight checklist. If we plot flight checklists with other flights we've flown, we see a marked improvement in that, which gives us confidence in stabilizing various parts of our job so they don't have to be retuned very much every flight. There are a lot indicators that give us confidence in that.

[Exhibit B-23.]

More having to do with the benefits. This gives you an idea of some of the geographical spread which I also had for you on another chart, and this gives you an idea on the number of contractors and people involved in the program and, approximately, their distribution. Jerry mentioned to you that we have about 3,300 civil service people here at Johnson. We have about 6,500 local contractors; so about 10,000 people locally in the immediate area. And in general, the program is spending $3½ billion a year throughout the country.

[Exhibit B-24.]

I said I wanted to talk to you about the possibilities—we have long believed that there were things that you could do that we hadn't gotten around to doing yet. We've done some experimenting with various processes for making pure materials in a pharmaceutical sense. It's a process called electrophoresis. Well, here it is and it flew on STS-4 and will fly again on STS-6.

McDonnell Douglas, in conjunction with Johnson & Johnson are involved in this attempt to use the space and the space platform provided by the shuttle as a way of producing some materials that they believe cannot produce as well or perhaps even at all when it comes to some degree of purity on Earth. They have been very optomistic in going into this program, and they have been very en-

couraged about the results so far. But I would like to make the point that Jim Rose came to see us several years ago, and he had this good idea, like Jim has often had in his career, and our reaction was, "Gee, don't wait to do this some later time. Let's design it so we can put it into the cockpit and fly it as soon as you can get it ready."

[Exhibit B-25.]

This is the lower deck of the orbiter by the hatch, right by the door. As a matter of fact, if we were flying a galley for the crew, it would be in this area, but we did not have one scheduled for the early flights, and we think on any given flight where this could be used for a galley, we'll be able to coax them out of using a galley by this device. And some of the control boxes for it are here, by the way. This is the floor of the mid deck. And it's really pretty exciting, but the point is that it is the kind of experimentation that we can do with the orbiter as a complete add-on to the orbiter flight. We flew it on the STS-4 at no extra effort to speak of and certainly at no extra cost for the Government to do that.

But in the process, this company—combination of companies were able to explore this technology just for the money associated, although it's not insignificant in building the hardware itself, and they didn't have to worry about the transportation costs. We were able to do it at a very minimal, easy-to-add-on way.

Congressman LUJAN. That brings up an important question. NASA keeps saying, "Well, we're not dedicated to a space station or a spacelab or anything," and that seems to me like, "Well, we're just talking," but we're really going and moving ahead. How can you take advantage of situations like this if you are not really sure if you're going to put in a space station or spacelab?

Dr. LUNNEY. That's a problem for the industry, because we can do this, and we can do it in the cargo bay, and there's some preliminary plans as to how we could deploy, if I may call this a factory, this small factory, put it in orbit. But an industry's plans for that certainly have to presume that they know that we are going to do some of this. And it's been a little difficult for us and for industry in the terms of saying we are going to have exactly this kind of capability by this kind of year available to you, other than what we are going to have available on a shuttle.

Chairman VOLKMER. I don't mean exactly this thing. You have it all ready to go and everything, but even apparently the decision that we are going to do it seems to be something that NASA does not want to talk about.

Mr. GRIFFIN. You're talking in terms of a space station or some kind of permanent station?

Chairman VOLKMER. Well, something permanent.

Mr. COVINGTON. We don't even know if we're going to make it that.

Mr. GRIFFIN. But the reality of it is that we are—it is not on an approved start, so therefore, we can't put the assuredness to it like we'd like to do, and you're going to hear a little bit more on what we're doing, but I believe it is—one of the areas that we are working on now is to find what the need for a space station is and what the requirements—what the requirements we will be satisfied with. I think experiments like this are one of the drivers that are going

to make that decision real clear to us as we go on. There are others besides just electrophoresis. But I think this could be—the manufacturing process in space could be one of the drivers for a space station, either permanently manned or man-tended or manned part of the time, or some kind of combination thereof. The reality of it is, though, that we are trying to get our act together and get the story together clearly and succinctly so the administration and the Congress can understand what it is that we are trying to devise, and that's not easy, because there are a whole hosts of potential uses. But when you start pinning those down, then that is what we are trying to do today. They are sometimes elusive; so that is where we are.

Dr. LUNNEY. There is some difficulty in building a consensus for that, because some people——

Chairman VOLKMER. Let's put it this way. Undoubtedly, there's mixed signals within the administration as to the need for such a thing, too, because of Dr. Keyworth's attitude, and then when we were listening yesterday to McDonnell Douglas people, the thing came out about the letter from Stockman to NASA on the use of the shuttle and priorities, how that affects the decision for more orbiters and the availability of flights. That impacts on these type of people, too, some.

Dr. LUNNEY. Yes; it does.

Mr. COVINGTON. Of course, they are threatening to go to France.

Chairman VOLKMER. But I mean, somewhere down the line we are going to have to decide where we are going.

Mr. GRIFFIN. Yes, sir.

Dr. LUNNEY. At the experimental stage, before they might know what they really want to do, it's convenient to handle them this way, and I think we can stay at pace with any needs.

Chairman VOLKMER. There's no problem now, but I'm——

Congressman LUJAN. Have you gotten some product already out of that experiment?

Dr. LUNNEY. Well, we haven't at NASA. I think their interest was more in a put-through potential than it was in a particular set of stuff that they could go analyze.

Chairman VOLKMER. I think this next one that goes up, or the sixth Shuttle flight, is more for purity. The last one was just a test-out to make sure that the equipment works——

Mr. GRIFFIN. This is a proprietary process and the product is proprietary, and that's one of the advantages that we have been able to work, is to let the company maintain a proprietary license. And as such, a lot of us are not aware exactly where they are with the thing, but it's obvious that it's worked well enough that they were very excited about it and are still putting resources into it.

Dr. LUNNEY. And I'll pass over another benefit that we get from the program; that's when it was leaving, the Challenger was leaving. I thought I'd pick through some pictures for you now of STS-5 just to show you what a typical mission looks like and it will answer some of your questions on the upper stage.

[Exhibit B-26.]

[Exhibit B-27.]

This is what the rockets look like. They are stacked in segments on the MLP. You can barely see the platform underneath here, but

in that middle picture you can see it. And it's below there and we stack these things up in a vertical assembly building, and you can imagine what this operation and the tank in the orbiter would be like out in a breeze at Vandenberg, which by the way, it blows 20 knots as near as I can tell almost all the time. So that is one of the reasons for some of the assembly buildings protective features out there. This is what the rockets look like stacked. They fire down into two holes. This is a hole where the engine—the main engines on the back of the orbiter will fire after we get it stacked.

These are what are called tail service masts, the umbilical that are released just as the orbiter lifts off.

[Exhibit B–28.]

[Exhibit B–29.]

This is what the tank looks like as it comes to Kennedy. This is what the tank looks like as it goes over the top and down. You can just see the nose cone, if you will, of the solid rockets on this side. That's not the nose cone; I take that back. This is the tank somewhere in the process of stacking. I can't tell you where the rockets are.

[Exhibit B–30.]

[Exhibit B–31.]

Here is Columbia coming in. It goes into a sling device like this to put it up vertical. It comes in, of course, on the wheels, on the tires, which have to be stowed, and then it goes, frankly, frighteningly high in the air as we begin to stack it to the tank in the vertical assembly building. You can see the three main engines, and the red cover is just a protective cover over the OMS engines, the orbital maneuvering system engines on the back end of the orbiter.

[Exhibit B–32.]

This is what it looks like all stacked up. The tail service mast is here, as you can see, connecting to two plates at the back end of the orbiter.

[Exhibit B–33.]

[Exhibit B–34.]

That's what it looks like going to the pad. That's what it looks like on the pad.

These were all, I believe, STS–5 pictures.

Congressman LUJAN. Do you ever think that orbiter will take off like an airplane rather than having launch it with rockets?

Dr. LUNNEY. No, not on this one; but maybe some day. But just the amount of propellant that you need, you need these solid rockets full of propellant and this tank full of propellant to run these three engines. You can conceive, perhaps, of making an orbiter that big, but there's a tremendous advantage of being able to stage some of this stuff away. But some day we may get the single stage——

Mr. GRIFFIN. There have been studies that looked at that, and there's indications that the Russians have done that as well.

Congressman LUJAN. You say maybe some day. Is that a very strong "maybe" or a very weak "maybe" that it's possible some day?

Dr. LUNNEY. It's possible some day.

Congressman LUJAN. Probable?

Dr. LUNNEY. I would answer it the following way: I don't know.

Mr. COVINGTON. As a matter of fact, the Air Force is looking at a version of that now where you take off horizontally on the back of an airplane; so we're getting to do it where you do get some staging that way. But if you're talking about just one Buck Rogers kind of a spacecraft that sits on its tires and goes down the runway and then flys into orbit, there's a technology question associated with the engines on that. You have got to have an engine, probably, that will act as a jet or ramjet and then a rocket with the injection of the right kind of rocket fluids into it, and there is no engine like that now. But the law of physics tells you that it is better, once you have used up a piece of your tank, to let it go and let it fly back.

Dr. LUNNEY. Instead of carrying it.

Mr. COVINGTON. Instead of carrying it, so I think the technology will probably come along in 20 years or so; but the question of the economics of it say you'll probably want to fly back the first stage and land it, whether it's an airplane or a spacecraft.

Dr. LUNNEY. And another part of that puzzle is going to be: What are we going to be doing, anyway? What are we really going to be doing with space stations or whatever they are, platforms, and how does all that fit together, et cetera.

[Exhibit B-35.]

[Exhibit B-36.]

[Exhibit B-37.]

This is what it looks like going, and that's what it looks like right over the cape taken from the Shuttle training aircraft. The rockets drop down 140 miles off the cape. The tank drops down in the Indian Ocean, and, of course, we flew for about 5 days, landing back at Edwards.

[Exhibit B-38.]

[Exhibit B-39.]

This is a rocket coming back down, one of the solid rockets with the drogue chute out. It then does employ three parachutes and bobs around in the water until we recover it.

This is a long-range photo of the orbiter with the three engines and the tank and two rockets having burned out and separated and away at staging time about 2 minutes into the flight.

Chairman VOLKMER. Don't move that first one because I want to ask about it. When the first, the small tanks drop off, how far up from——

Dr. LUNNEY. About 140 miles up the coast.

Congressman LUJAN. There is some problem about Interior leasing some of the offshore oil, but they wouldn't lease it 135 miles out; would they?

Dr. LUNNEY. Even less than that, I think, because we've looked at——

Congressman LUJAN. They would lease it less than that, sure; but I mean, where do those tanks fall?

Dr. LUNNEY. They fall that far out where the due east launches were; you're going as far from the cape as you can. If you want more northerly, you tend to go up the coast, if you will, of the United States, and they drop closer to the continental United States.

Chairman VOLKMER. But your Shuttle launches are due east?

Dr. LUNNEY. Not all of them. We have some—the Spacelab goes to 57° so it's kind of at the——

Mr. GRIFFIN. It's aimed about at Europe.

Dr. LUNNEY. So you aim it north on the PanAm route to London, practically, or a little bit north of London when it gets there, but it goes that way.

Chairman VOLKMER. In that regard, can I ask you one other question. because I've always wondered about this. You set a trajectory; it's all pretimed and everything else. And that orbiter stays basically, once it gets basically in that orbit, in orbit using the OMS to make minor corrections. Why can't you—in other words, why can't that orbiter vary and then come back in?

Mr. GRIFFIN. You're talking about changing——

Chairman VOLKMER. Right. You're talking about due east, but for one trip around, you decide you want to fly a little bit out this way and then, halfway around the world, come back in.

Mr. GRIFFIN. That's a good question, and we do make minor changes in plane of the orbit, but not in a major way because it is a physics reason. It is extremely costly to change the plane of the orbit. It takes a lot of velocity change in order to affect a relatively small change in the orbit plane with respect to the equator. Now, you can change the altitude of an orbit fairly easily. We do that quite a lot. It's not quite as sensitive.

Dr. LUNNEY. Yes; we do do that.

Mr. GRIFFIN. But it's extremely a lot—we will do some plane variations within the constraints of the orbital maneuvering system, but there is just not enough capability there to say, for instance, go from almost equatorial to almost pole. That would take a tremendous amount of velocity.

Dr. LUNNEY. If you know the orbiter is going 25,000 feet per second this way, and if you wanted to change its course just 45°, you would have to put 25,000 feet per second to the left; so you would have to put the energy into that that comes from those solids in that big tank to make it change 45°.

Dr. LUNNEY. So you're going very, very fast, and if you want to deviate it, you have got to put an awful lot in it to point it in another direction.

[Exhibit B–38.]

[Exhibit B–40.]

Solids coming back, towed by one of two ships that we have down there to do that. And this is a picture of the flight crew on orbit with the wires and papers and equipment floating around.

The deployment sequence; you've asked about that. The PAM-D's—by the way, PAM for propulsion assist modules, D for Delta class. A lot of communication satellites come to us sized for flying on a Delta launch vehicle, one of ours which has flown for 15 years.

[Exhibit B–41.]

This is what one looks like. It's in this little cocoon on a pallet like the other pallets you saw before, only covered over with this insulation. And the idea of the insulation is just to keep the satellite warm. There's little heaters inside mounted on this thing which radiantly heat the satellite, and this top is buttoned up closed when they're on orbit just to keep them nice—it's a thermos bittle effect. Just keep them nice and comfortable.

There's actually two of them on this flight, one behind this one. They open the doors; there's a platform that spins up which gives it then the stability that you get from spinning like a bullet, and then we blow the pyrotechnics at the right moment with the orbiter pointed in the right direction, so it's like aiming a rifle, also. The satellite is spinning, and then once the pyrotechnics are blown, four springs on each side, 90° apart, push it out; and that's what it looks like riding out of here.

[Exhibit B–42.]

Forty-five minutes later, this motor fires, and then it separates from the vehicle and it goes on up into a high altitude where another engine is used to kick it into a geosynchronous orbit 22,000 miles above the Earth.

Chairman VOLKMER. That satellite is also traveling at the same rate of speed as the shuttle, 25,000 feet per second?

Dr. LUNNEY. Yes, per second, until we fire this engine and that changes the altitude of it considerably.

Chairman VOLKMER. That will change the altitude, but not——

Dr. LUNNEY. Excuse me. We do have——

Chairman VOLKMER. What about the velocity?

Dr. LUNNEY. At a change in the altitude, you have to add velocity. But they also do some amount of plane change. In other words, when they go out of the orbit there in the 28th—they're going 28.5° above and below the equator, they correct that as they go up in the first burned end and the second burn, so that they are then flying right over the equator; so as the Earth rotates, they rotate at the same rate and, in effect, stay at the same point above the Earth.

[Exhibit B–43.]

[Exhibit B–44.]

That's what it looks like going out. This is what it looks like a little bit further away. And to protect the windows, we make the crew turn away so they don't get to see the burn and they're kind of disturbed and disappointed about that; but they survived.

[Exhibit B–45.]

[Exhibit B–46.]

There's four of our friends. And this is what the OMS engines back in those pods look like when they were used. It's just interesting, the light of the picture.

[Exhibit B–47.]

[Exhibit B–48.]

This is what our conception is of what an orbiter might look like coming in. The pilots did remark on the glow coming in. We took them to an angle attack which made more of the glow around the ship come toward the windows. They commented on that and then backed away from it and it went away and they felt a lot more comfortable, but it was more of an emotional thing than a technical one. But they commented on it.

[Exhibit B–49.]

[Exhibit B–50.]

[Exhibit B–51.]

This is *Columbia* coming down at Edwards. That's what it looks like landing. As a matter of fact, it had rained, and it's not two oribters but it's the reflection.

[Exhibit B–52.]

Putting it back on the top of the 747 where we brought it back to Cape Kennedy.

[Exhibit B–53.]

On landing on the shuttle landing facility at the cape. This tail cone is put on just for protection, really, of the 747 tail area; otherwise, it would have been an extremely turbulent area. The tail cone tends to smooth all that out.

[Exhibit B–54.]

[Exhibit B–55.]

I won't go through these word pictures, but in the beginning of the program, we were worried about four areas. We worry about engines—that's what SSME stands for, space shuttle manned engines—and in a word, they work very well.

We worried about the avionics system. It's very complex. Five computers plus a sixth spare we flew all lashed up running this ship in a digital way. We only had one problem in flight. It's the same problem you have at home. The TV screens would not work sometimes. We got two, three, four, five or so of those on board; and it was things like clogged filters causing the power supply to the CRT to overheat.

A big interest in the area of thermal protection system on the orbiter. We had a variety of problems, but they're all of the type where we were able to learn a great deal about that problem and about other problems that might occur, and we found that some of the problems that we studied after STS–2 helped us when we got hit with hail the night before launch on STS–4. So that is all going pretty well.

[Exhibit B–56.]

This is what some of the tile loss was. This is some of the tile lost that occurred on STS–3 forward.

[Exhibit B–57.]

This is some of the tile lost that occurred on the OMS POD on the first flight, we think, due to some things coming off the tank. We had a lightening band on the tank, and although there's some debate still, we think that the way we tied the lightening band into the tank came off in flight, and as you can see, it would streamline back here just about the right way and bang the OMS POD; so we took it off and we don't have it now.

[Exhibit B–58.]

We also had some tiles on the back—this is the body flap on the bottom of the orbiter and that's the engine. We also had some tiles lost here. On STS–2 we had a problem in that we took rain on the pad and some of the caps or the tops of the tiles popped off because they were wet. We got rain inside the cracks. Probably, in some zeal, although we can't prove that, the next flight we kind of overwaterproofed, it looks like, on some of the tiles, mostly on the top side. When someone was spraying this Scotchguard—literally, Scotchguard on the tiles on the top side, we think they probably got a little too much on. And that picture you saw of the nose a minute ago, and this area on the body flap were lost probably due to that.

[Exhibit B–59.]

This is some debonding that we saw on the tank, and that was just mostly a process problem, getting better gluing of the ablator to the tank.

[Exhibit B-60.]

We had one problem of significance in the structural dynamic area. We found when these rocket engines—as solid rocket motors go off, and you remember the hole I showed you in the platform; well, this hole was open before, and we believe that there's a shock wave that goes down from the motor when it ignites and it bounces back up and it rattles the vehicle considerably at takeoff. So what we did was we built the setup, water pipes around a nozzle to quench this shock wave or this genie as it goes down in the hole, and then we put this cork into the bottle to keep the genie in there, if I could continue that, with the water then serving as a way of not allowing the thing to come out. And we use water rather than big plates or something because that introduces a whole new set of problems. After you take off, when you hit it with the plume, because you'll get more noise and acoustics building up around the ship, the water is no problem at all once the vehicle turns up as the water tears these bags, which are made out of sailcloth, and it doesn't remain there as a problem. You only find pieces of it afterward.

[Exhibit B-61.]

[Exhibit B-62.]

So that was something else we learned on the first flight, and we've had that system in place throughout. We had a lot of other events. The remote manipulator we moved to Northrup strip on the third flight. A couple of days before the launch we said—Edwards went bad with rain, so we got two convoys of trains and we moved 42 cars and I don't know how many people halfway across the country to a much more comfortable area, and they enjoyed the trip and their stay there. We've extended on orbit now—as a matter of fact, we did on that flight. The first time we were going to land at Northrup strip, it was blowing a little bit and we stayed in orbit. We had hail damage, which our experience in understanding water and tiles and how it behaves allowed us to work our way and launch on time. We lost a set of solid rocket boosters because the parachute system—not the parachute itself, but the circuits that control it failed.

We had some problems with the suit systems on the last flight, which we believe are fixed now.

STS-4 and 5 went up on time. The payload deployments on time, and in the crew debrief we got a report that the crew felt that they never got behind, which is the first time in recorded manned space flight history that a crew was able to say that to us in this room. So it's a comfortable time line and comfortable control of the work. And we had four people on board for the first time rather than the two. Two people on board really were burdened in the first four flights. We were trying to do an awful lot and there was an awful lot that was unknown, and two people scrambling back and forth from the flight deck to the mid deck and doing all the things that they had to do turned out to be quite a load on two people. Four people is a lot more comfortable. And the teams all around are in good shape and they're improving.

We had a lot of other experience with customers. We had almost a little bit of everybody. We had communication satellites; we had the McDonnell Douglas experiment, if I can call it that; we flew a DOD payload and a couple of other center payloads; and we had a variety of more minor things that weren't major payloads.

[Exhibit B-63.]

[Exhibit B-64.]

[Exhibit B-65.]

STS-6: It's much more of an operational base line. The orbiter is new. It's in a class—the next three orbiters, including this one, are classed by themselves. Different from Columbia. External tank you know about. Solid rocket boosters; we've taken weight out of the case. Main engines; and we used a different hanger, in effect, for the orbiter. We're using the second mobile launcher platform. We've had a review all last fall of the different configurations up to and including one with the Administrator.

Congressman LUJAN. Before you go on, since you're giving us all the different things that you've done, one of the concentrations has been on reducing the operational costs so that you don't have to charge people so much for using your services. How are you doing on that?

Dr. LUNNEY. We're doing reasonably well, I would say, but probably not as well as any one of us would like. I think we'd like to do better across the board.

Congressman LUJAN. It is cheaper now to get one into orbit than it was for the first one?

Dr. LUNNEY. Well, there's two different things going at work here. One is——

Congressman LUJAN. Well, the first shuttle shot versus the fifth one.

Dr. LUNNEY. Oh, it cost us far less this time out per everything that we had to do. It took us less time in the facilities; but then they're not very valid comparisons because we're flying so seldom in terms of what the cost is. But in terms of what we learned, we've seen significant learning in how to process the orbiter, how to process the hardware; so it gives us a lot of confidence that as the team learns how to do this—a variety of small things can be done to improve the turnaround time at the cape and float time and the amount of hours it takes to get one to take off.

Congressman LUJAN. We were reading yesterday where you were estimating originally 160 hours turnaround time, and its's actually 888. Is it less than 888?

Dr. LUNNEY. Well, right now I don't know what the number is. It could well be that. But let me put that into context for you. The 160 was more a goal for the program. Shoot for that and see how close you can get; 160 hours is 2 weeks at two shifts' work, and we said, well, why don't we shoot for 2 weeks. It's a nice round number. We now have studies on the books with known specific fixes or modifications that would allow the flow to get to 24 working days by the mideighties—and by the way, we don't need it—we don't even need it that well by that time. So as opposed to what you might call 10 working days and the 160 hours, two shifts, we've got it planned where in 24 working days we think we can turn an orbiter around.

Chairman VOLKMER. Two shifts?

Dr. LUNNEY. No, that would be probably three, although the third one is more reduced, a catch-up kind of a shift. So we are not reaching the goal yet, and that's kind of what it was; but we're making a lot of stride, and you can see the kind of things that people come forward to fix that they are thinking about; what will I have to do to make my job easier.

[Exhibit B-66.]

The sixth flight to the pad on a low wind day, but a lot of ground cover.

[Exhibit B-67.]

This is what the cargo configuration looks like on the sixth. Tracking and data relay satellite in the inertial upper stage. The McDonnell Douglas experiment flys again, and we have three get-away special canisters from different people.

[Exhibit B-68.]

To give you some idea of the size of these things—this is not what I want to show you first, but this is what a get-away special can looks like. They're really pretty thick.

[Exhibit B-69.]

This is what the IUS stage and the TDRS satellite look like in this canister, which is a replica of the cargo bay of he orbiter. The inertial upper stage goes up to here, and it is a two-stage rocket. It is deployed not right out of the bay like I showed you the PAM-D's. But it is released here and then rotated up to about 45 degrees. And then when it's time to go, we fire pyrotechnics to release it and it shoots off up over the cockpit, the front end of the ship.

This is the satellite of he PAM-D. The rocket puts about 1,100 pounds on geosynchronous orbit. This configuration puts about a 5,000-pound satellite; that's what the TDRS weighs approximately on geosynchronous orbit. So there's quite a difference in size of the satellite.

Congressman LUJAN. TDRS is going on number 6?

Dr. LUNNEY. Yes, sir, 6 and 8.

[Exhibit B-70.]

That's a firing at the cape. We've had two of those, and we're still struggling with clearing the aft end of hydrogen. We've had a leak that we've detected. We had one firing in December. We did a lot of tests with argument about where the leak was. We did it again with more instrumentation. We were able to isolate it to an engine. That engine's been removed. We're in the process of replacing it; however, the first engine, that is, the spare engine, we had to replace it, also had a leak, and we now have the second engine that's completed its acceptance testing at NSTL and is going through final leak checks. We're hoping to get it to the cape by Monday, this coming Monday, and we're struggling with that.

We also sent, by the way, one of the engines that flew on the Columbia down to the cape. It's not what we would want to use because it's a lower thrust engine, but if worse comes to worst, we have that.

[Exhibit B-71.]

Future mission planning: It's too hard to read this thing, but it gives you some idea of the new things that are happening in the program as we go along. STS-9, the Spacelab 1. STS-10 is this fall;

it's a DOD mission. Then a variety of other first steps, including the first flight from Vandenberg and launch pad B up here in 1986. The first Centaur is planned—the first two Centaurs are planned in the month of May in 1986. They're the two inter-planetary missions, one, the Galileo, an American one, and second, the International Solar Polar Mission built by ESA.

[Exhibit B-72.]

[Exhibit B-73.]

Here's the spacelab in work at the cape in some stands, that is, the blue stuff is the stands. These are the racks. Ultimately, I think they slide into this pressurized compartment, and it's in the process of doing through its checkout at the cape, and it will fly approximatley in a configuration like that.

[Exhibit B-74.]

Next year, we have a mission schedule on flight 13 that involves the repairing of a satellite that's on orbit. We're going to fly up in the orbiter, rendezvous with the satellite, which, by the way, you're right up against in this view, so it's the size of the satellite that will fit in the cargo bay. One of the pilots is going to fly over, hook up to it, put another fixture on it, and then maneuver it back to the shuttle with the thrusters available on the manned maneuvering unit. We're going to catch it, put it in the shuttle bay, repair it, and put it back up next year—April, May—flight 13.

[Exhibit B-75.]

This is just an upgrade that we're making in the solid rocket booster cases. They are now steel, about a half-inch thick. We're going to a new material that we use in a lot of other solid rockets—as a matter of fact, it's used in the PAM and used in the IUS. It's a composite material. It's a graphite composite that's wound on things that look like great big looms where they wind these cases for solid rockets.

Chairman VOLKMER. Is that Hercules?

Dr. LUNNEY. Yes; Hercules is doing that work. It's beautiful work, if you've ever seen one.

[Exhibit B-76.]

This is another picture of the shuttle launching the Centaur, as I've showed you before.

I'm going a little fast so I let the other guys have time to talk.

[Exhibit B-77.]

Some idea of the customers that we have. We've got about 14 different commercial organizations, commercial satellite organizations that we're working with, and if you've counted the total number of satellites, it would be on that order of 38, close to 40.

Likewise, in NASA we're working with about 33 different organizations interested in flying about 43 payloads. DOD here, and the foreign, which is primarily communication satellite business. So every week we have two or three different organizations come to the center here working over a period time, probably 3 years or so, from the time they start building their satellite until they get it ready to launch. We work with them here and at the cape in flying.

[Exhibit B-78.]

You've seen this mission model, which is the number of flights out of two sites accumulating to 24 by 1988, and we can reasonably

see the traffic that would support that kind of model. Our budget planning is to achieve that ramp up in flight rate, and that in itself is surprising. It is a powerful driver on all of the things that we do, and a powerful driver on teaching us what we don't have to do anymore. Just in order to do that, 24 flights is one every payday, one every 2 weeks; so there's only so much time to hand tailor each flight.

[Exhibit B-79:]

We deal with the Air Force on a lot of subjects. There are various organizational ties, hearing committees, coordination groups tied together. We coordinate on the budget to be sure that those things are right. They are contracting for Vandenberg launch site, and we're working with them in a variety of ways to get that built. We work with them on the payloads that they want to fly, the 10 or so payloads that they're presently here talking to us about flying; we work with them on that. We worked with them on the inertial upper stage, which actually the Air Force is contracted with Boeing to build, and this is, in effect, buying it from them for the TDRS mission. We're working with them on Centaur where they've joined our development process. We've been flying Centaur for years, managed by Lewis Research Center, with General Dynamics as the prime contractor. They've joined us because they're interested in having a version of this for the future. They're working on a thing called Consolidated Space Operations Center in Colorado, which is consolidated in that it is designed to handle their satellites on orbit as in addition to Sunnyvale, the SCF operation that they have at Sunnyvale Control Facility up at—in Sunnyvale near San Francisco. Also, a shuttle operation's planning part of the facility is where the consolidated comes from, because it's both a present satellite and a shuttle plan for the future.

Congressman LUJAN. Shuttle monitoring on takeoff and——

Dr. LUNNEY. Shuttle planning of flights and then control of the flights as we do from our control center. Of course, we work with them on security. We've been working with them since 1976 here at this center on the secure missions and what we have to do to handle those, et cetera.

[Exhibit B-80.]

Our perspective is that the system works and it works very well. We're still going to continue to have our normal series of problems, I suppose, for a while; but the hardware, the orbiter, the space shuttle as a whole, the teams of people that work with it, and the flight software that has—all the flight software and the ground software, it all works pretty well.

You know, our concern is that we have to be highly conscious of managing the risks properly. We don't want to do anything that invites a flight failure, because we just don't see any room to tolerate it.

We're involved in different techniques with high flight rate, high to us. Our max in the past was five per year. We've got a few orbiters, so we're working on various tools, techniques and delegations of authority and decision levels to make that happen. We're worried about and will continue to worry about good quality in a production environment. By production, I mean the higher and higher the flight rate goes, the more routine—a word we have some suspi-

cion of—but the more routine things comes—and that's good, but we still have to be sure that we're doing things to insure that the vehicle and the crew will be OK.

We're going to struggle with this problem because we have to balance wide spread information and easy access, which is a key to success, with security which involves shutting down all that stuff as a key to security and protecting what we have to protect. So that's going to be a balancing—juggling act for us as we go along.

We talked about other ways to operate the shuttle. We see our job for the present is to do it as well as we can, put as many good ways of doing business into being that we can for the future, and to maintain whatever options the country might want to exercise and how to do that. Everybody would like to see some more activity, but that's already been discussed in terms of what we might do in terms of a platform or station.

The good that that does us, speaking purely from the local viewpoint, perhaps, is that it helps the process of getting people who might otherwise tinker with a program off it. In other words, if there's two good things to do, the organizations will all tend to find their own level of doing both of them; but the longer you have one program, that is, the STS to which an awfully lot of people are dedicated, there's a tendency sometimes to—well, there's a tendency to find problems we have to find, but we also in the process find problems that maybe we really don't need to work on, but we tend to work on them because they certainly have to be dealt with.

Congressman LUJAN. That security question. Isn't it pretty difficult to secure, say, something like a satellite or something. Can anybody just tune in on the right frequencies?

Dr. LUNNEY. We put these things they call—we call them KG boxes; I don't know why we call them that. But it's a form of encryption or scrambling the data, which I could not describe how it works. But it scrambles up the data, and then you unscramble it when you get it on the ground.

Mr. GRIFFIN. You have to know the code.

Dr. LUNNEY. That's a standard technique that they've been using for years. As a matter of fact, we're putting such devices on board the orbiter, not for classified missions necessarily, but just as a matter of protecting the orbiter as a national resource. We're going to encrypt, as it's called, the telemetry signals and the voice up and down from the ground to the orbiter as it flys starting with flight 10, I think.

So conceivably, I guess, it could be tuned in on, but, I guess, the people who are responsible for that—other parts of this Government don't think so, and they think they've got a good system for protecting radio links for either data or voice; and we'll be doing that.

Chairman VOLKMER. I have just a couple of questions. On the space suit, you said——

Dr. LUNNEY. We went fast over that.

Chairman VOLKMER. Yes; you don't give the phrase out "it is fixed now."

Dr. LUNNEY. Yes; it's fixed and we have more permanent fixes in mind. What I mean by that is the fan—the little chip that controls the fan motor that we had a problem with in one of the suits is

probably being in a more moisture environment and getting moisture into it and degrading the operation of this little chip which controls the motor.

What we've done now is screened them. By that, I mean use ones that are low timed, that haven't been in much moisture, they haven't been exposed to very much of that, and we know that they haven't shifted in characteristics at all. So we're kind of using relatively new controllers and their motors as the fix—temporary fix for flight 6 by carefully selecting the ones we're going to fly. Plus, we're flying, by the way, three systems for two crew members, so that even then we could afford to take another problem like that and still have another suit available.

In the future, we're looking at better covering—sealing of the chip or maybe putting it in a different place so that it's not subject to the moisture of the suit that the people are in—getting into the part and degrading it; so we may end up having a different kind of a process for the chip and locating it in a different place or something like that. So that's a longer term fix. But we're comfortable that the fixes and the screening that we've done on this flight will result in two good flight suits.

Chairman VOLKMER. Second question on thrust and payload. Several years ago when we first started this, we envisioned having—I don't remember the exact figure, but——

Dr. LUNNEY. 65,000 pounds.

Chairman VOLKMER [continuing]. 65,000 pounds, and we're only what—40,000—not even 40,000 yet?

Dr. LUNNEY. Well, these TDRS's that we're flying—we're flying at least 50,000 pounds of cargo on this next flight, TDRS and getaway special cans that McDonnell Douglas is flying.

Chairman VOLKMER. Not that it has to be, but do you envision that it will——

Dr. LUNNEY. Yes; we have them planned. It goes up year by year as the number of improvements come in. Galileo is the first mission that we have to fly 65,000 pounds out of Cape Kennedy, and we're quite confident that we'll be able to do that with one of the later orbiters, which is even lighter, again, than Challenger at the cape by several thousand pounds. But we have a plan to do that.

Chairman VOLKMER. By better engines?

Dr. LUNNEY. Better engines and a whole variety of things.

Chairman VOLKMER. One more question, and that is on the number of astronauts that we presently have as against the number of planned flights. Where are you 5 years from now as far as astronauts?

Mr. GRIFFIN. Mr. Chairman, if we could hold that answer to that question a bit. George Abbey has a whole discussion of this astronaut subject.

Chairman VOLKMER. Fine. My only question was that you have to get up there to those 65,000 pounds not only to be able to send up those experiments; but on a cost basis, if we're going to be—I don't like to say "truck line" up and down——

Dr. LUNNEY. At some point that's true. However, it's surprising that if we put four of these commercial communication satellites up like we flew last time—we put four which is the maximum that

we have wires for in the cargo bay, it only weighs 40,000 pounds. So there are only a few missions which——

Chairman VOLKMER. Are you going to get that 65,000?

Mr. GRIFFIN. It is a density question. Actually, what happened is that many of the cargo that we envision going into space, we are volume limited before we hit the maximum weight. We've seen that commercially—Galileo is one of the ones; it's a big vehicle and it's densely—it's got a lot of fuel in it and it's highly sensely packed.

Congressman LUJAN. If we're going to build cities up in space, we're going to have to take up cement and sand.

Dr. LUNNEY. When the system was based on a load factor of, I believe, 75 percent as a full load for pricing purposes, because we knew that much like a trucking line you would not always want to drive the system at a maximum weight. So you had to base your pricing policy based on a three-quarter full cargo bay.

Next, we will have a discussion of the orbiter project in some detail. Tom Moser is the deputy project manager for the orbiter and will present this part of the story.

[Exhibits B-1 thru B-80 of Dr. Lunney's oral presentation follow:]

SPACE SHUTTL

E PROGRAM

636

DR. LUNNEY

19-605 O—83——41

NASA-S-83-00475
SPACE SHUTTLE PROGRAM
OVERVIEW AND STATUS
USA
Dr. G. S. Lunney

NASA-S-83-00470

SPACE SHUTTLE PROGRAM

OVERVIEW AND STATUS

(DISCUSSION TOPICS)

- GENERAL OVERVIEW
- SHUTTLE SYSTEM DESCRIPTION
- PROGRAM ORGANIZATION
- BENEFITS TO THE NATION
- A TYPICAL SHUTTLE MISSION (STS-5)
- STS 1—5 MISSION RESULTS
- STS-6 MISSION STATUS
- FUTURE MISSION PLANNING
- NASA/AF RELATIONSHIP
- PERSPECTIVE FOR THE FUTURE

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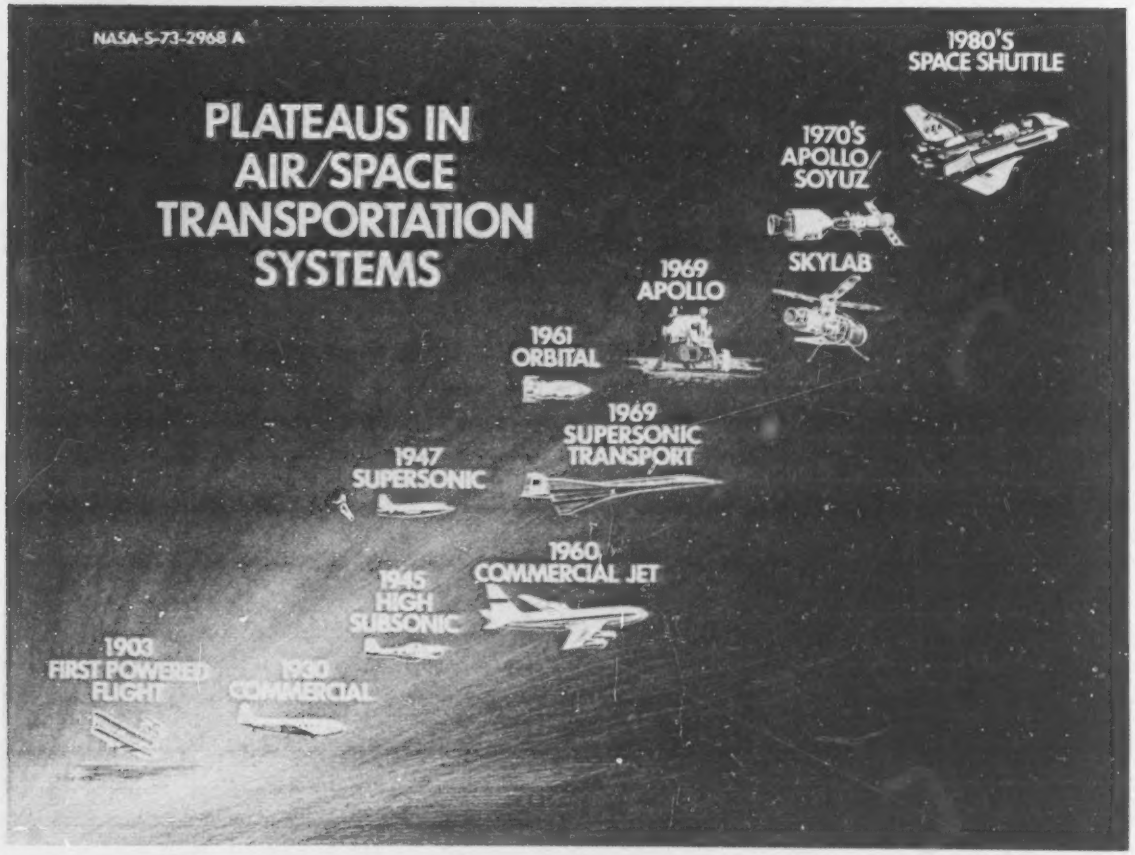
SPACE SHUTTLE PROGRAM

GENERAL OVERVIEW

NASA National Aeronautics and Space Administration

Lyndon B. Johnson Space Center



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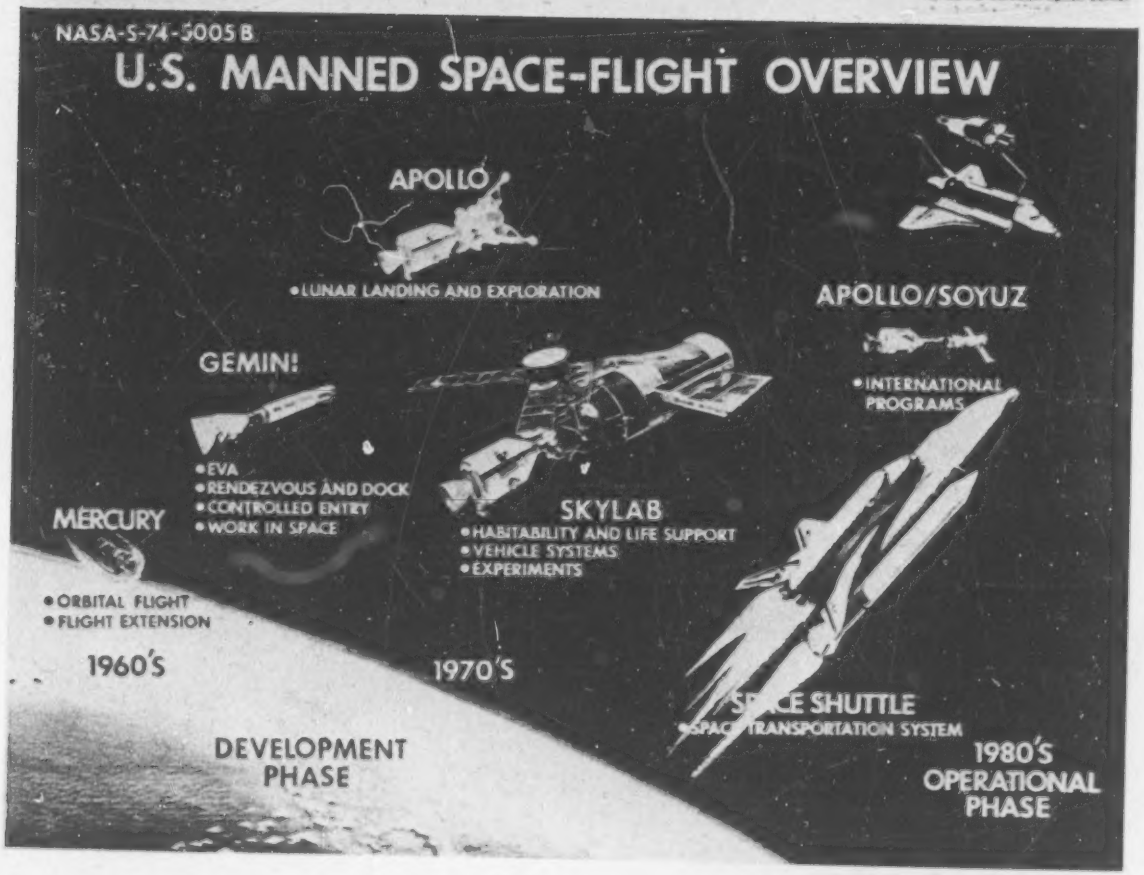

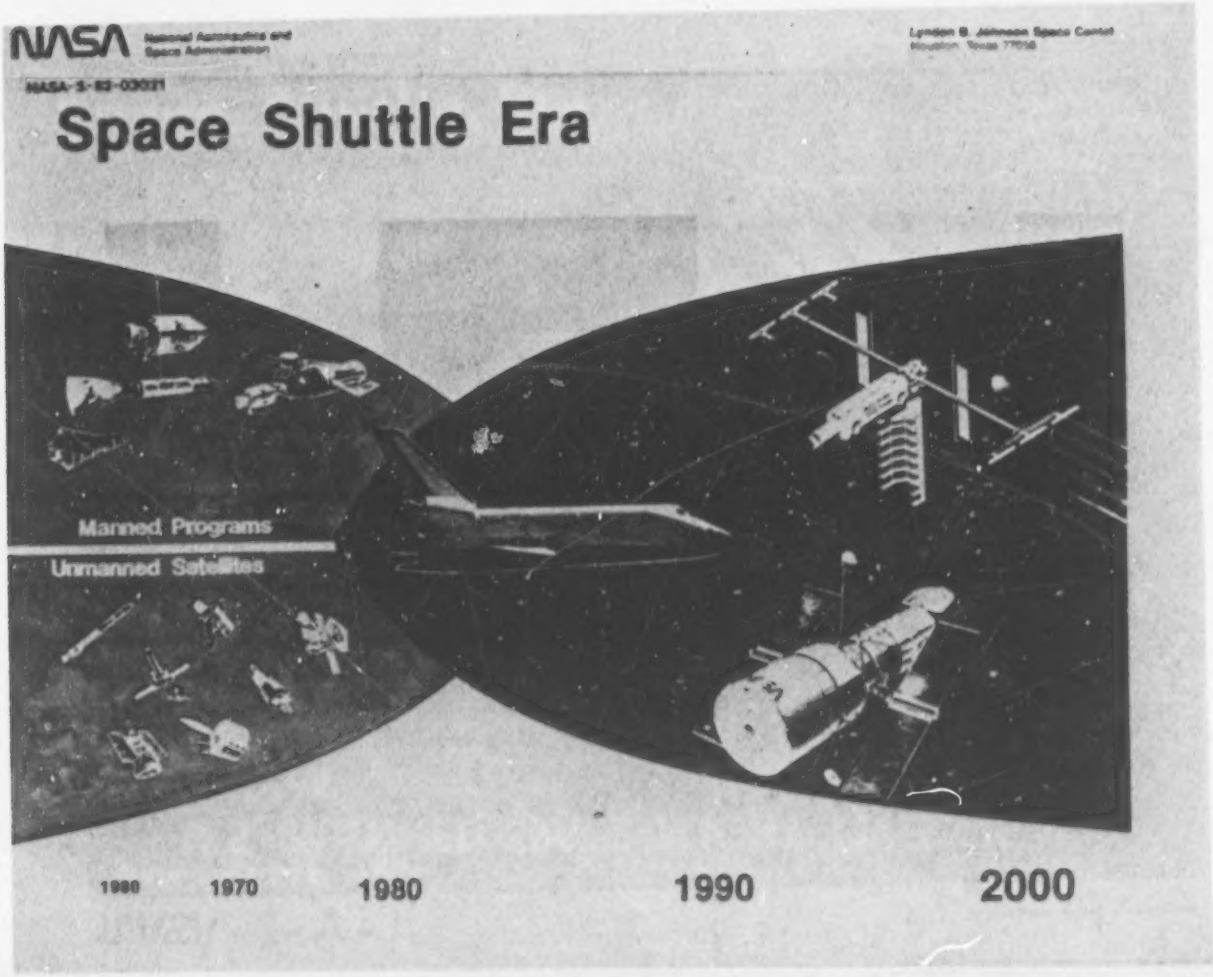
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Space Shuttle Era
Manned Programs
Unmanned Satellites
1960
1970
1980
1990
2000

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Space Shuttle
Program Objective
To establish a national space transportation capability that will:
• Substantially reduce the cost of space operations
• Provide a capability designed to support a wide range of scientific, applications, defense, commercial, and international uses.
NASA
United States

NASA-S-83-00456

SPACE SHUTTLE PROGRAM

644

SHUTTLE SYSTEM DESCRIPTION

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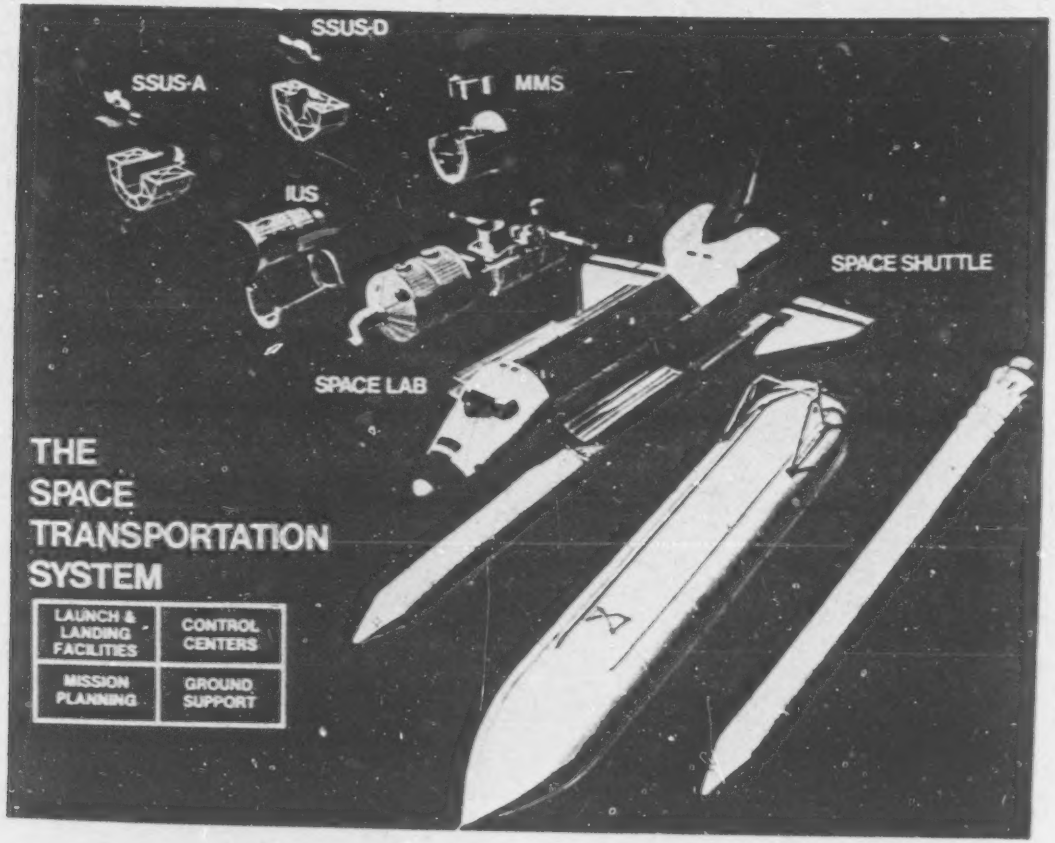

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ORBITER FLEET
DISCOVERY
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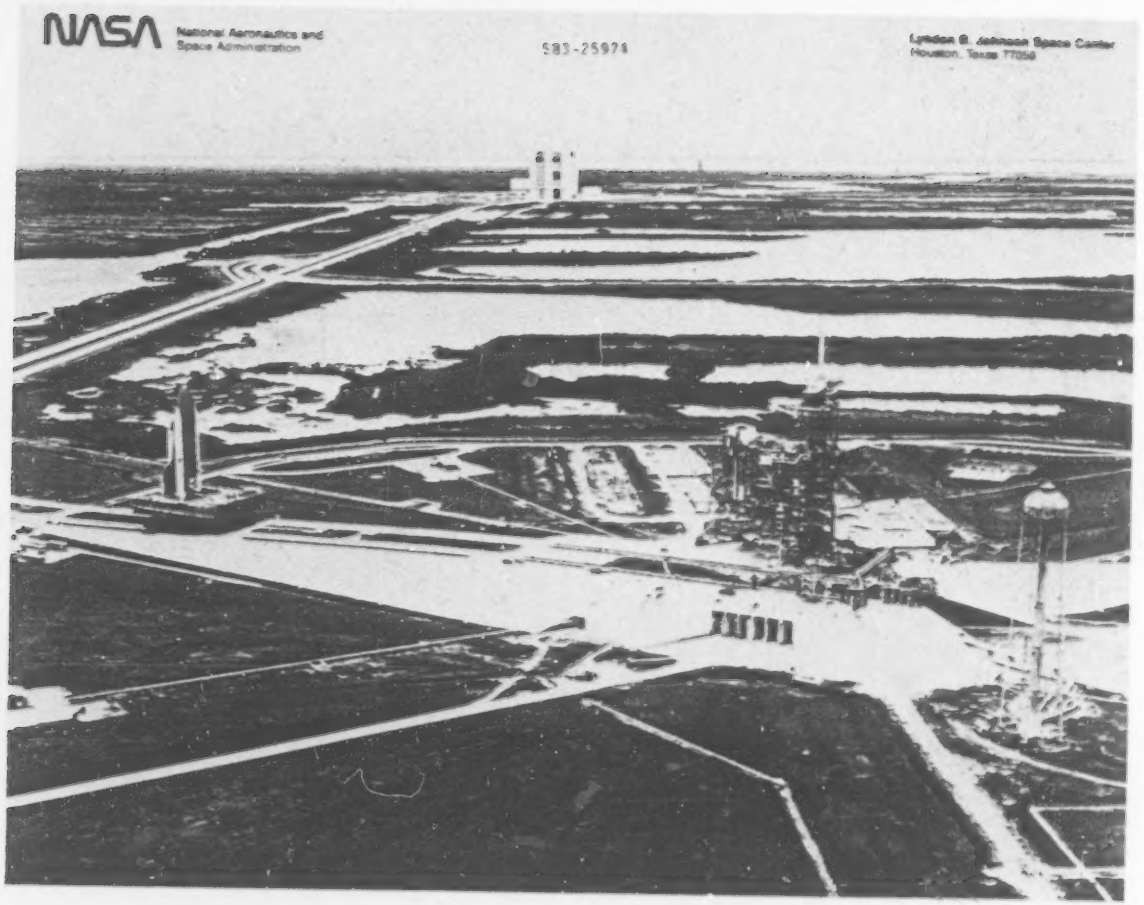
CHALLENGER
ATLANTIS
DECEMBER, 1984
COLUMBIA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SPACE SHUTTLE FACILITY AND SUPPORT LOCATIONS

NASA-S-83-00462

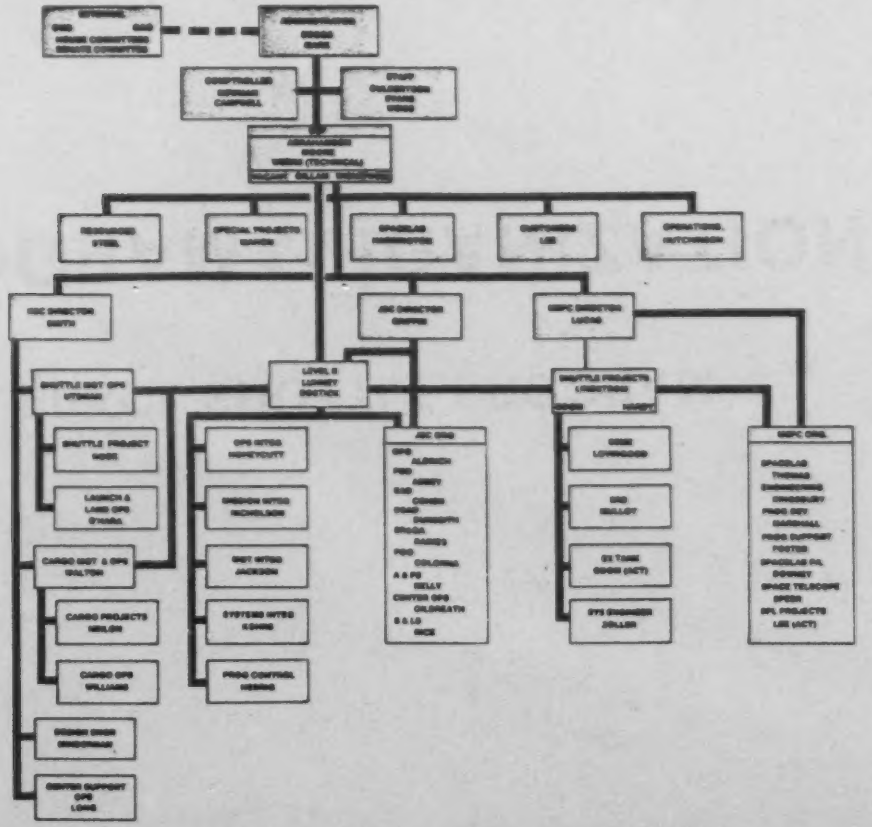
SPACE SHUTTLE PROGRAM

651

PROGRAM ORGANIZATION

NASA-S-83-00476

SPACE SHUTTLE MANAGEMENT RELATIONSHIPS



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SPACE SHUTTLE PROGRAM

ORGANIZATIONAL APPROACH

- LEAD CENTER CONCEPT
  - SMALL HQ STAFF
  - SPACE SHUTTLE PROGRAM OFFICE LOCATED AT JSC
- APPLICATION OF A WORK BREAKDOWN STRUCTURE TO ALL ELEMENTS INCLUDING THE GOVERNMENT ACTIVITIES AND MANAGEMENT
- PROGRAM OFFICE MANAGES PROJECTS, PROJECTS MANAGE CONTRACTS
- "INTEGRATION" IDENTIFIED AS A GOVERNMENT ROLE
- PROJECT MANAGERS PLACED IN A LINE RELATIONSHIP
- CAREFUL DOCUMENTATION AND CONTROL OF MANAGEMENT AND TECHNICAL REQUIREMENTS AT ALL ORGANIZATIONAL LEVELS
- TELECONFERENCING TO REDUCE TRAVEL
- EXTENSIVE DOD/USAF PARTICIPATION

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NASA-S-83-00123

SPACE SHUTTLE PROGRAM
GOVERNMENT/INDUSTRY TEAM

FUNCTION	GOVERNMENT	INDUSTRY
• OVERALL POLICY AND DIRECTION	NASA HQS	
• PROGRAM MANAGEMENT	JSC, LEAD CENTER	RI/SD - SYSTEMS ENGINEERING AND INTEGRATION SUPPORT
◦ PROGRAM PLANNING AND CONTROL ◦ SYSTEM INTEGRATION ◦ OPERATIONS INTEGRATION ◦ MISSION INTEGRATION		MDTSCO - SHUTTLE ENGINEERING AND OPERATIONS SUPPORT
• PROJECT MANAGEMENT		
◦ ORBITER	JSC	RI/SD PRIME
◦ SSME	MSFC	RI/RD - PRIME
◦ ET	MSFC	MMC - PRIME
◦ SRB	MSFC	USBI - PRIME
◦ SRM	MSFC	THIOKOL - PRIME

NASA-S-83-00457

SPACE SHUTTLE PROGRAM

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BENEFITS TO THE NATION

NASA-S-83-00481

SPACE SHUTTLE PROGRAM
BENEFITS TO THE NATION

- SCIENCE AND APPLICATIONS
- NATIONAL DEFENSE
- ECONOMIC BENEFITS
- POTENTIAL NEW TECHNOLOGIES/INDUSTRIES
- NATIONAL PRIDE AND PRESTIGE

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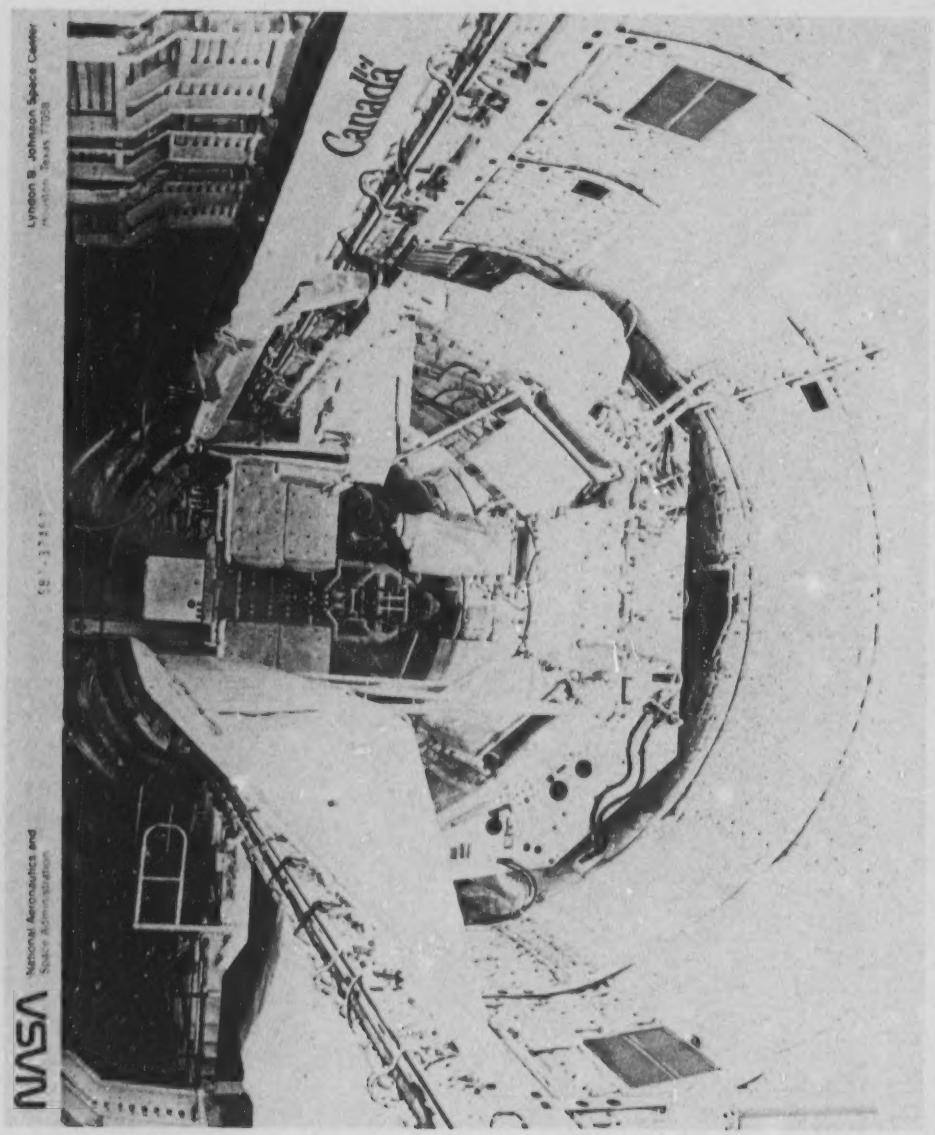
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Canada

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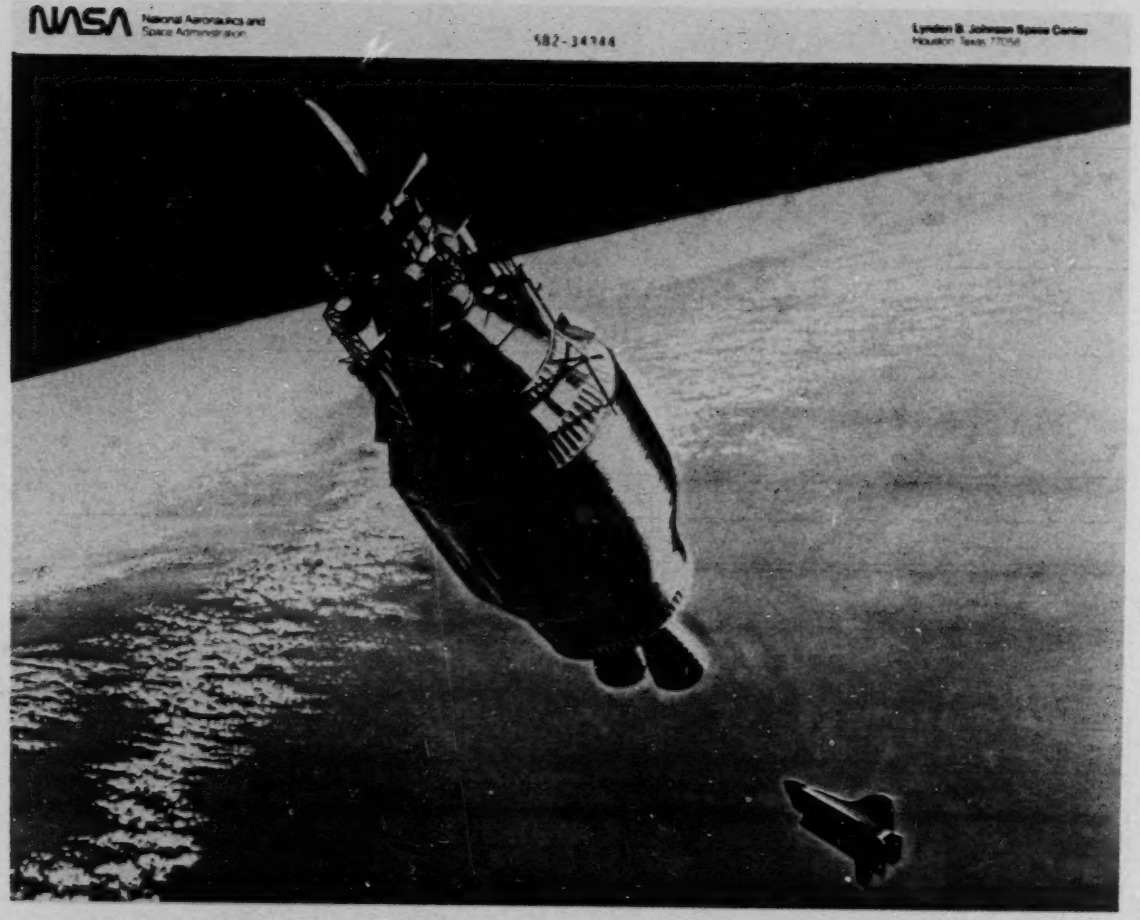
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MANNED SPACE FLIGHT SUMMARY

OPERATIONAL FREQUENCY

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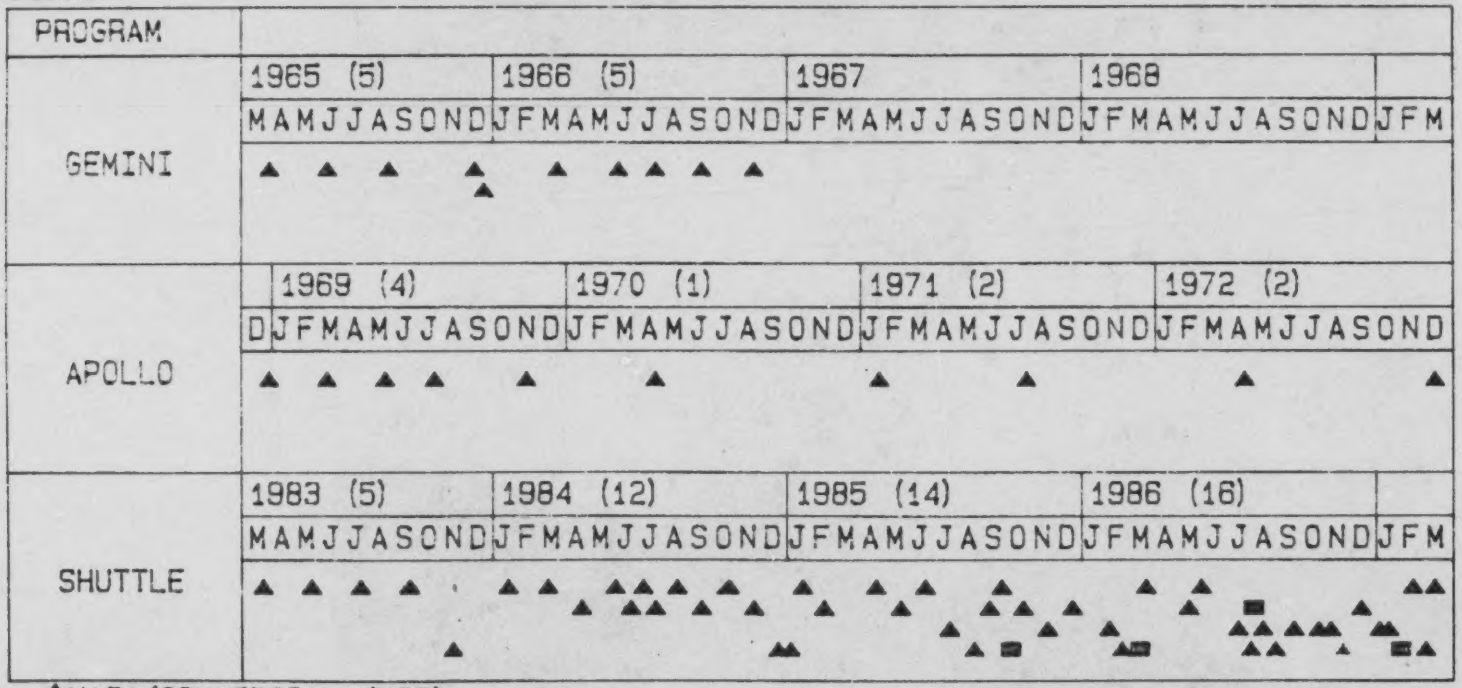
PROGRAM
GEMINI
1965 (5)
1966 (5)
1967
1968
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APOLLO
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▲ NASA/COMMERCIAL (KSC)
■ NASA/COMMERCIAL (VAFB)
▲ DOD (KSC)
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▲ MIXED (ALL KSC)

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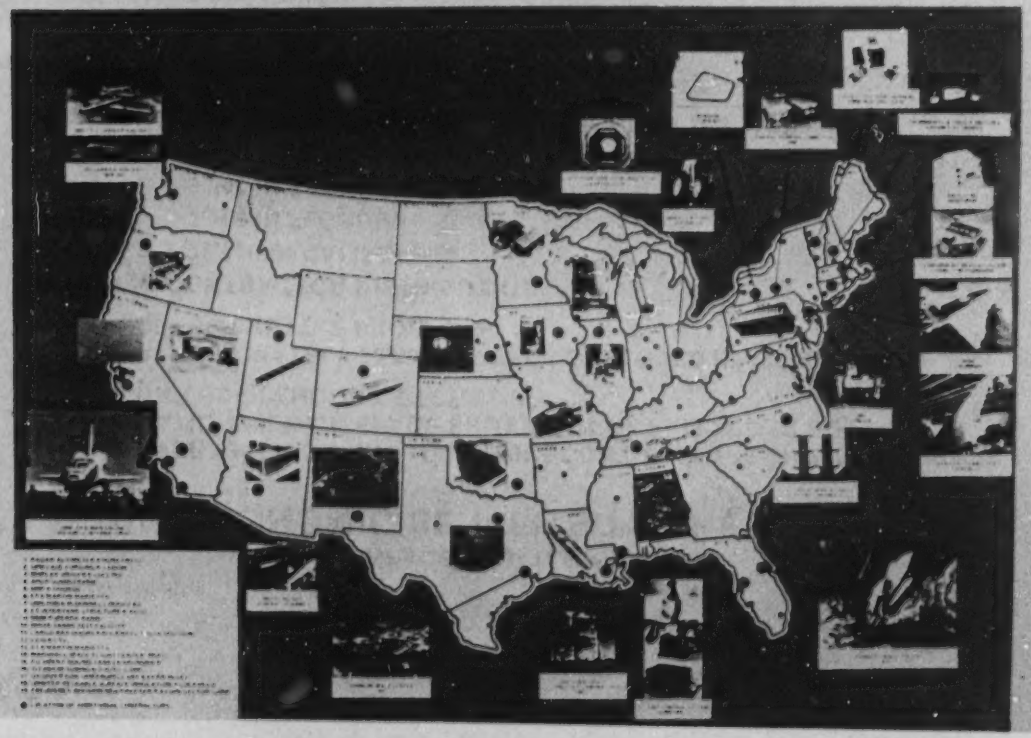
NATIONWIDE INVOLVEMENT IN SPACE SHUTTLE PROGRAM



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SPACE SHUTTLE PROGRAM

ECONOMIC BENEFITS TO THE NATION

- OVER 130 PRIME AND MAJOR SUBCONTRACTORS EMPLOYED NATIONWIDE ON SPACE SHUTTLE PROGRAM. (DOES NOT INCLUDE VENDORS, ETC)
- APPROXIMATELY 50,000 CITIZENS EMPLOYED NATIONWIDE ON SPACE SHUTTLE PROGRAM
  - CONTRACTOR DISTRIBUTION
    - 22,000 IN CALIFORNIA
    - 7,200 IN FLORDIA
    - 5,500 IN TEXAS
    - 3,400 IN LOUISIANA
    - BALANCE DISTRIBUTED THROUGHOUT U.S. NORTHEAST, MIDWEST, ETC.
  - CIVIL SERVICE DISTRIBUTION
    - 3,300 AT JSC
    - 2,200 AT KSC
    - 3,500 AT MSFC
- SPACE SHUTTLE PROGRAM IMPACT TO NATIONAL ECONOMY, APPROXIMATELY 3.8 BILLION DOLLARS TO BE SPENT BY FEDERAL GOVERNMENT DURING FY 1983

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SPACE SHUTTLE PROGRAM

STS-5

A TYPICAL SHUTTLE MISSION

667

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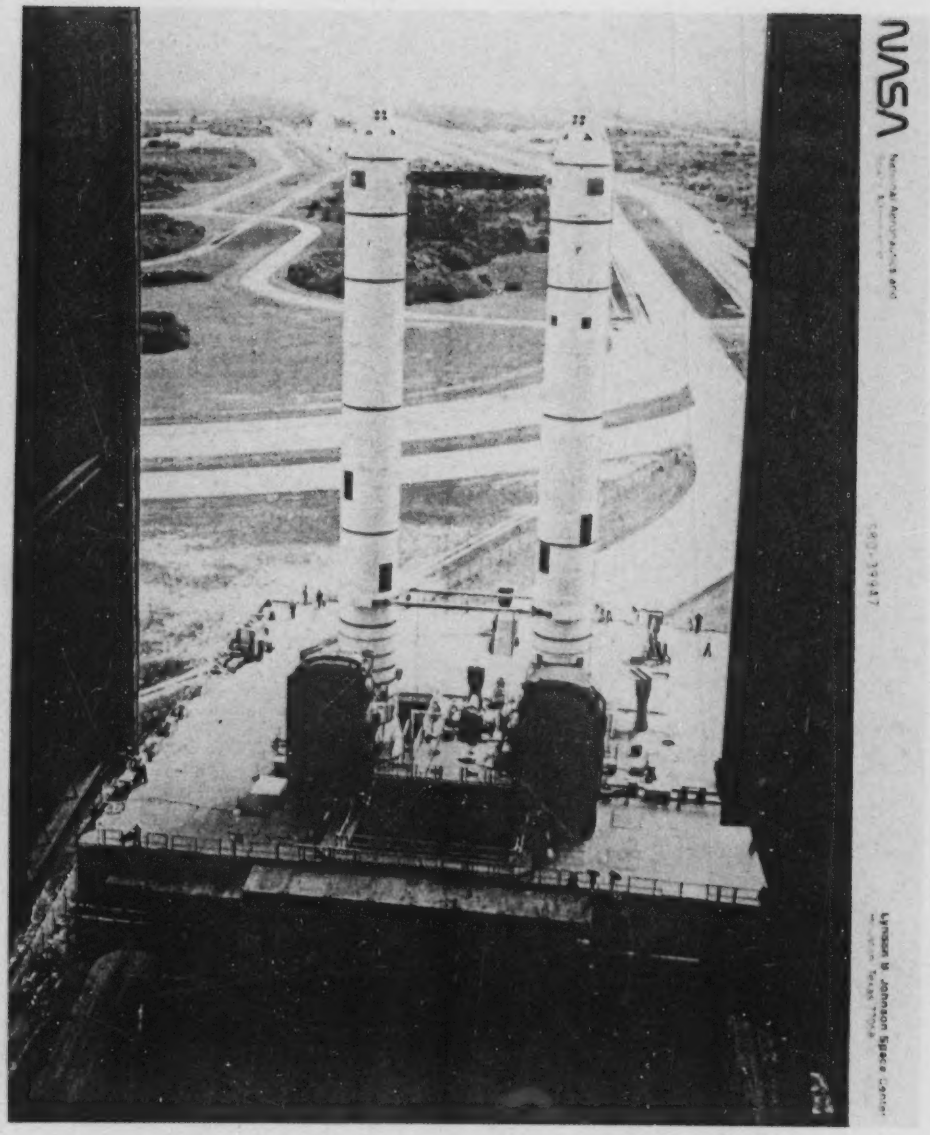
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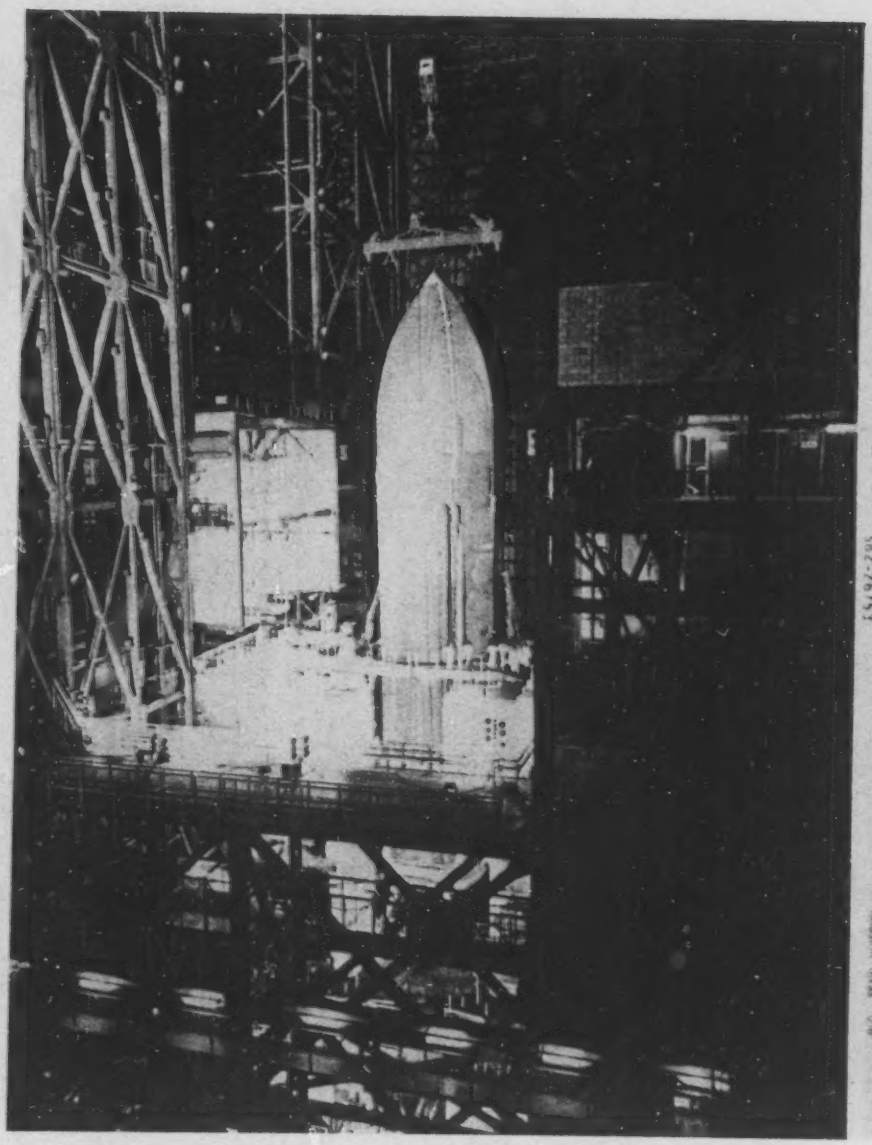
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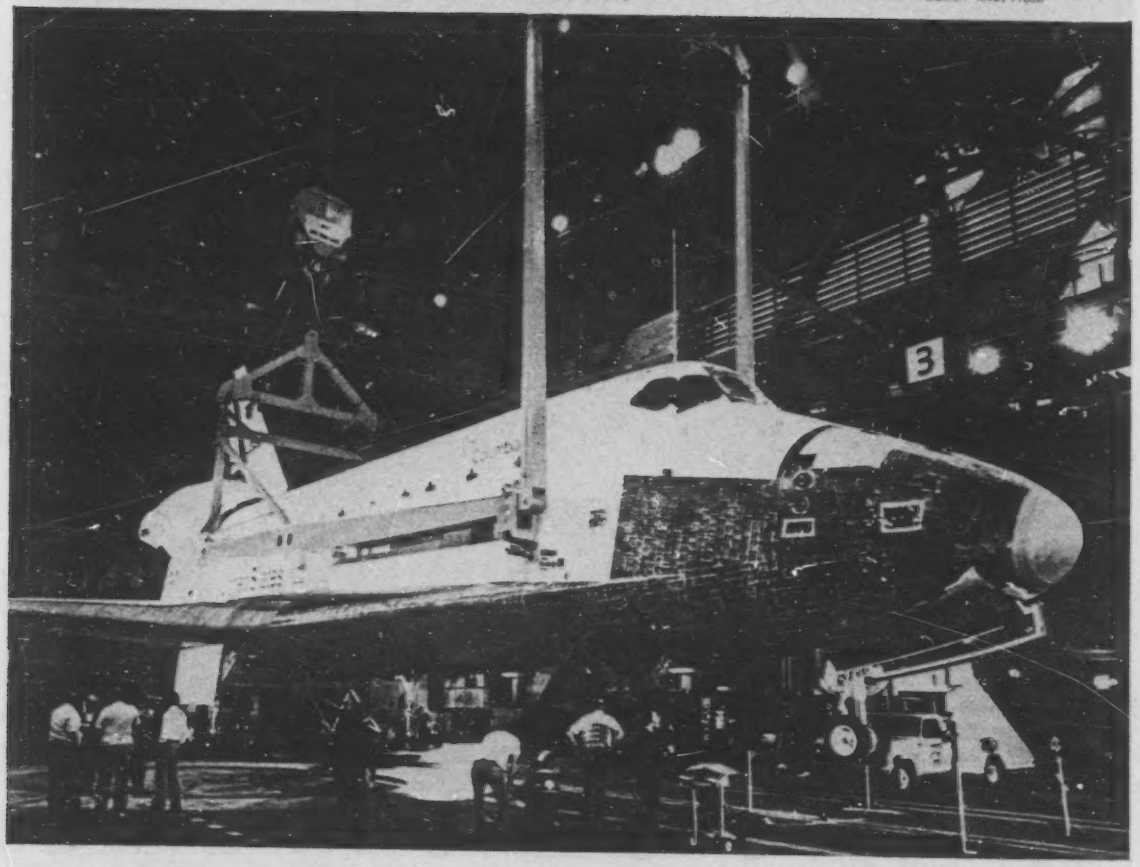

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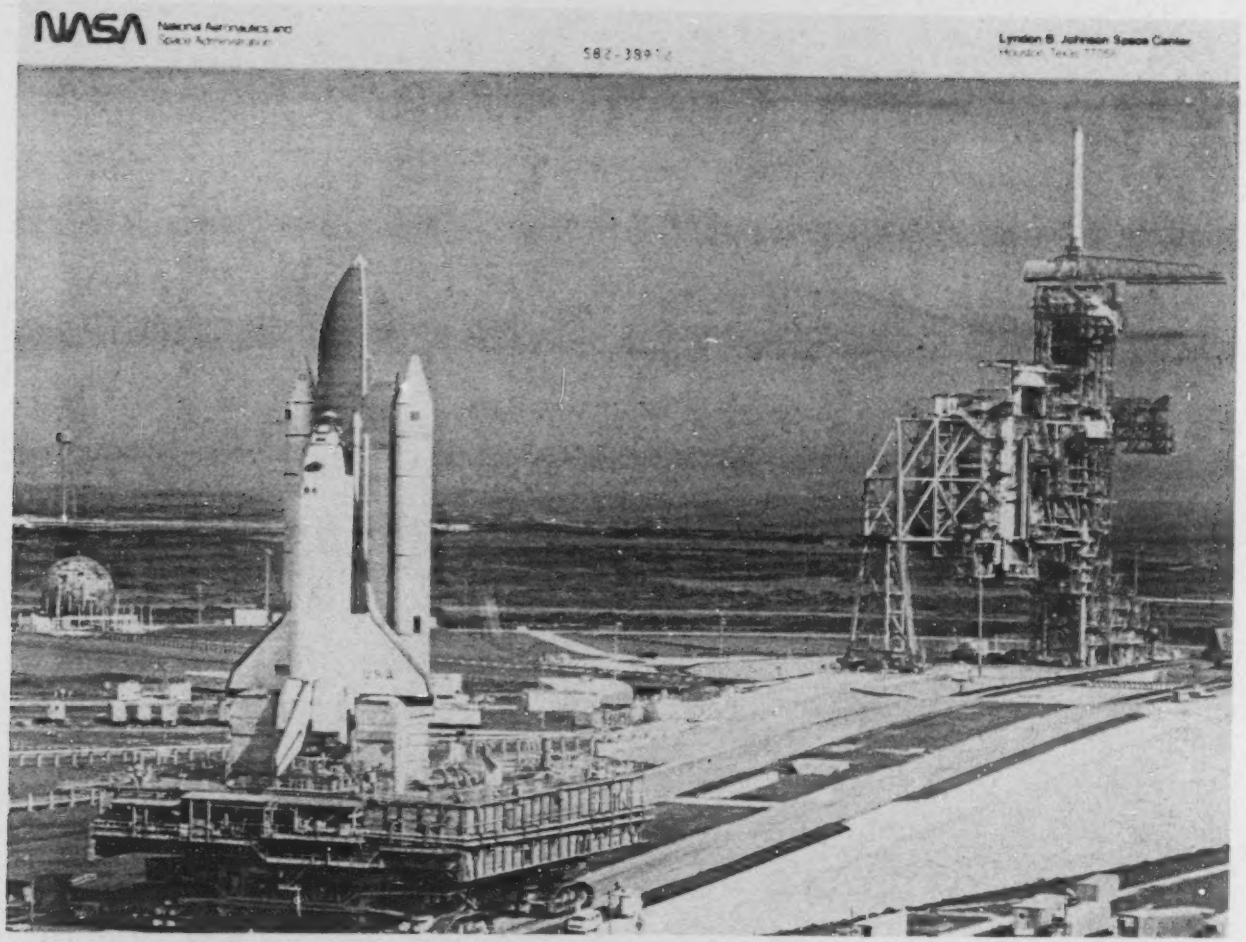
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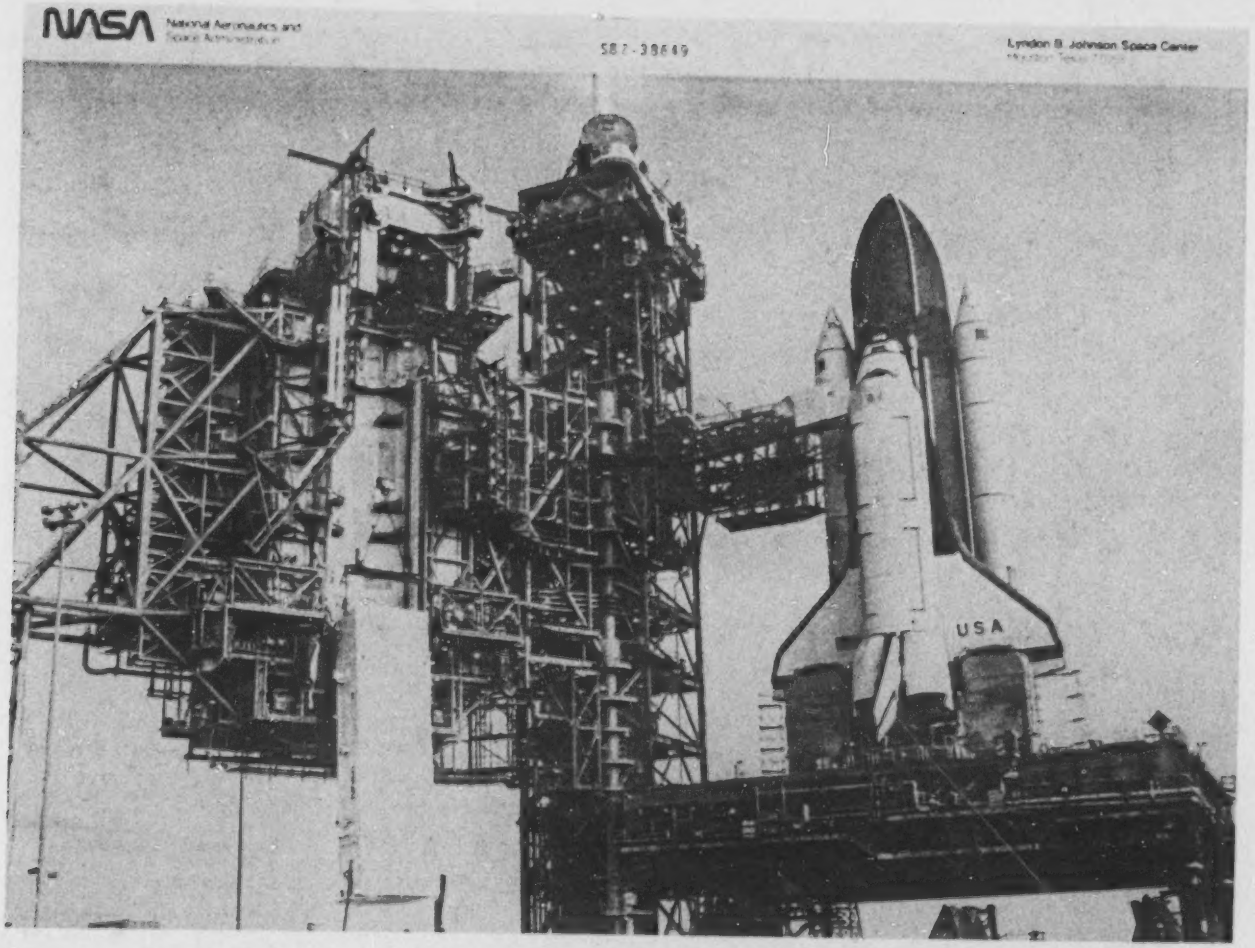
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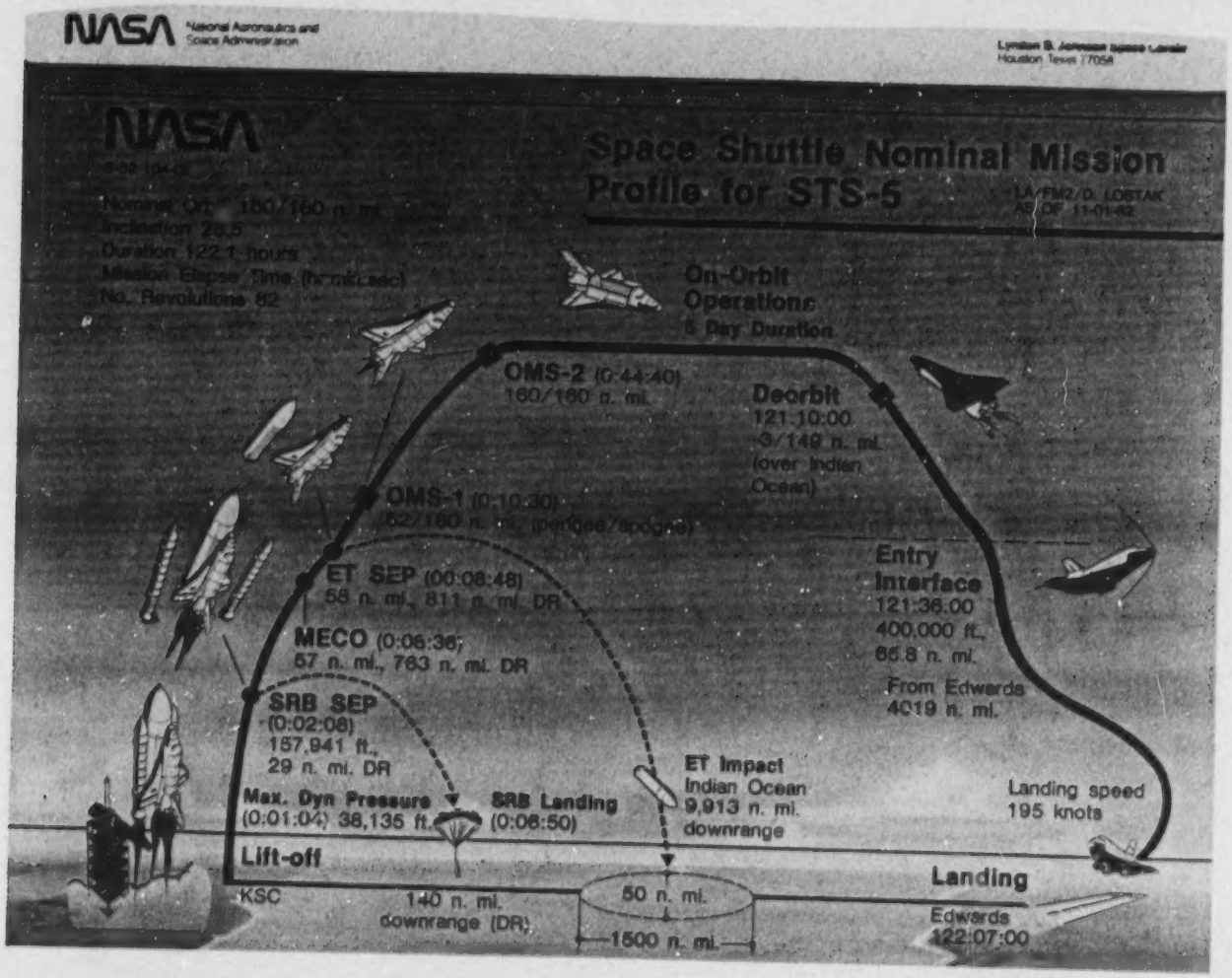
USA


NASA
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
Houston, Texas 77058
NASA
Space Shuttle Nominal Mission Profile for STS-5
LA/FM2/D. LOETAK
AS OF 11-01-82
Nominal Orb. 150/160 n. mi.
Inclination 28.5
Duration 122.1 hours
Mission Elapse Time (hr:min:sec)
No. Revolutions 82
On-Orbit Operations
5 Day Duration
OMS-2 (0:44:40)
160/160 n. mi.
Deorbit
121:10:00
3/149 n. mi.
(over Indian Ocean)
OMS-1 (0:10:30)
62/160 n. mi. (perigee/apogee)
ET SEP (00:08:48)
58 n. mi., 811 n. mi. DR
Entry Interface
121:36:00
400,000 ft.
66.8 n. mi.
From Edwards
4019 n. mi.
MECO (0:06:36)
57 n. mi., 763 n. mi. DR
SRB SEP
(0:02:08)
157,941 ft.,
29 n. mi. DR
ET Impact
Indian Ocean
9,913 n. mi.
downrange
Max. Dyn Pressure
(0:01:04) 38,135 ft.
SRB Landing
(0:06:50)
Landing speed
195 knots
Lift-off
KSC
140 n. mi.
downrange (DR)
50 n. mi.
1500 n. mi.
Landing
Edwards
122:07:00

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S82-28747

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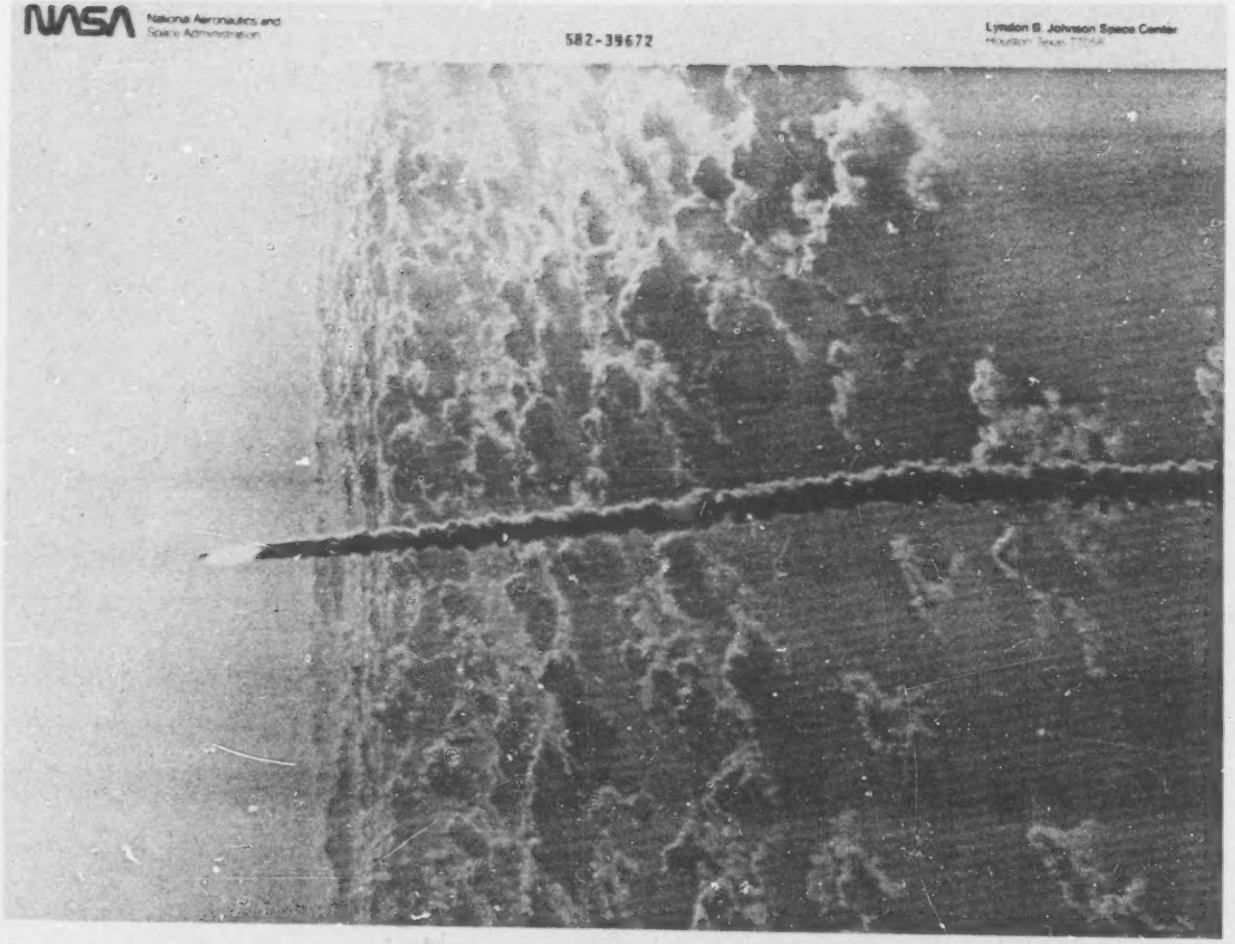
678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680

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S82-28481

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Space Administration
S81-31764
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STS-5-10- 376

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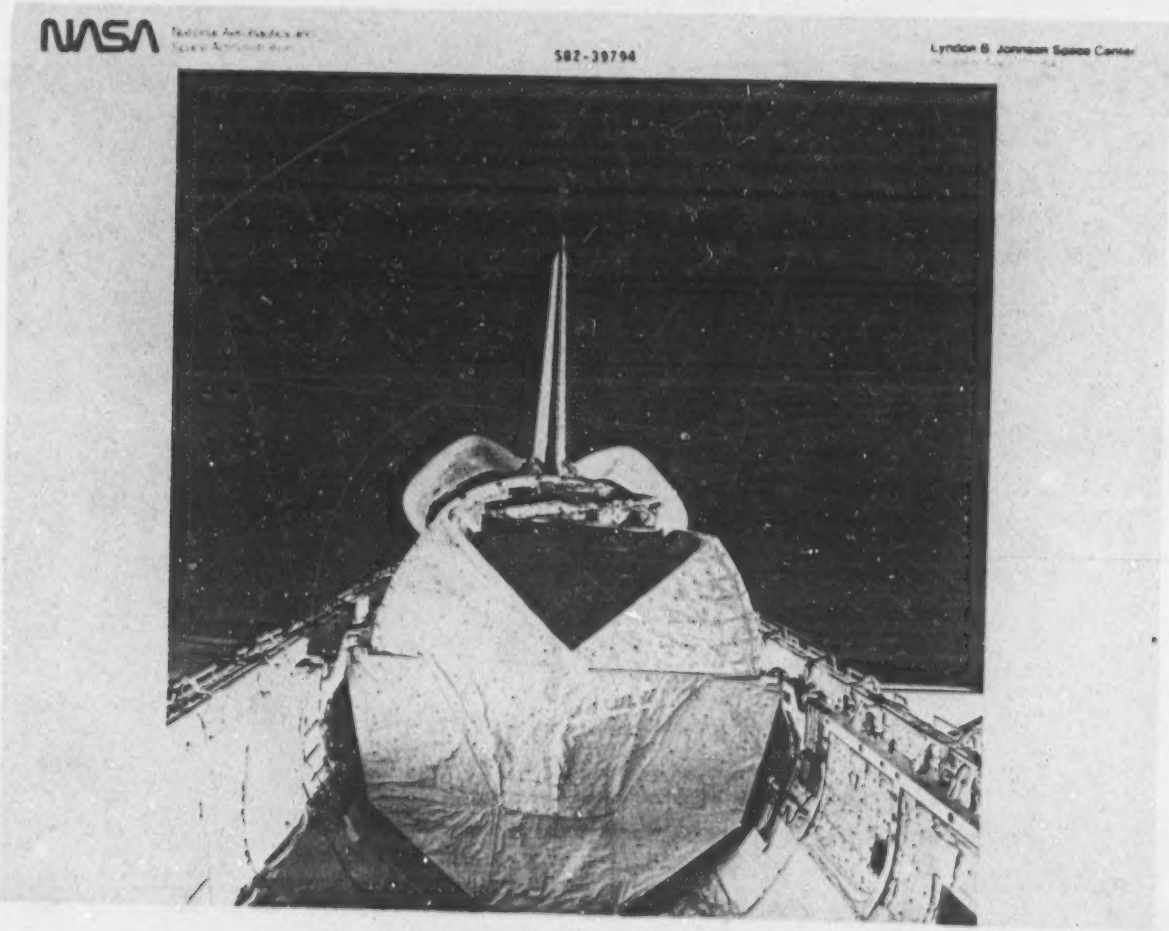
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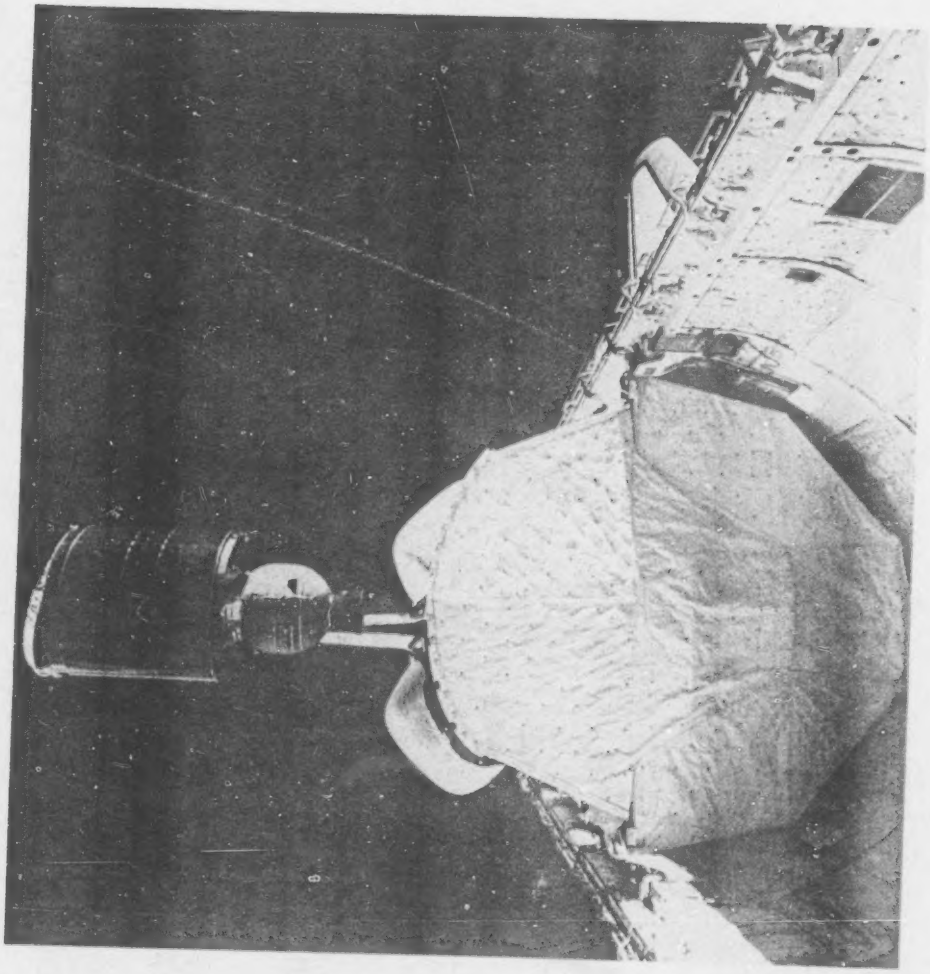

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S82-39802
Ace Moving Co.
"We Deliver"

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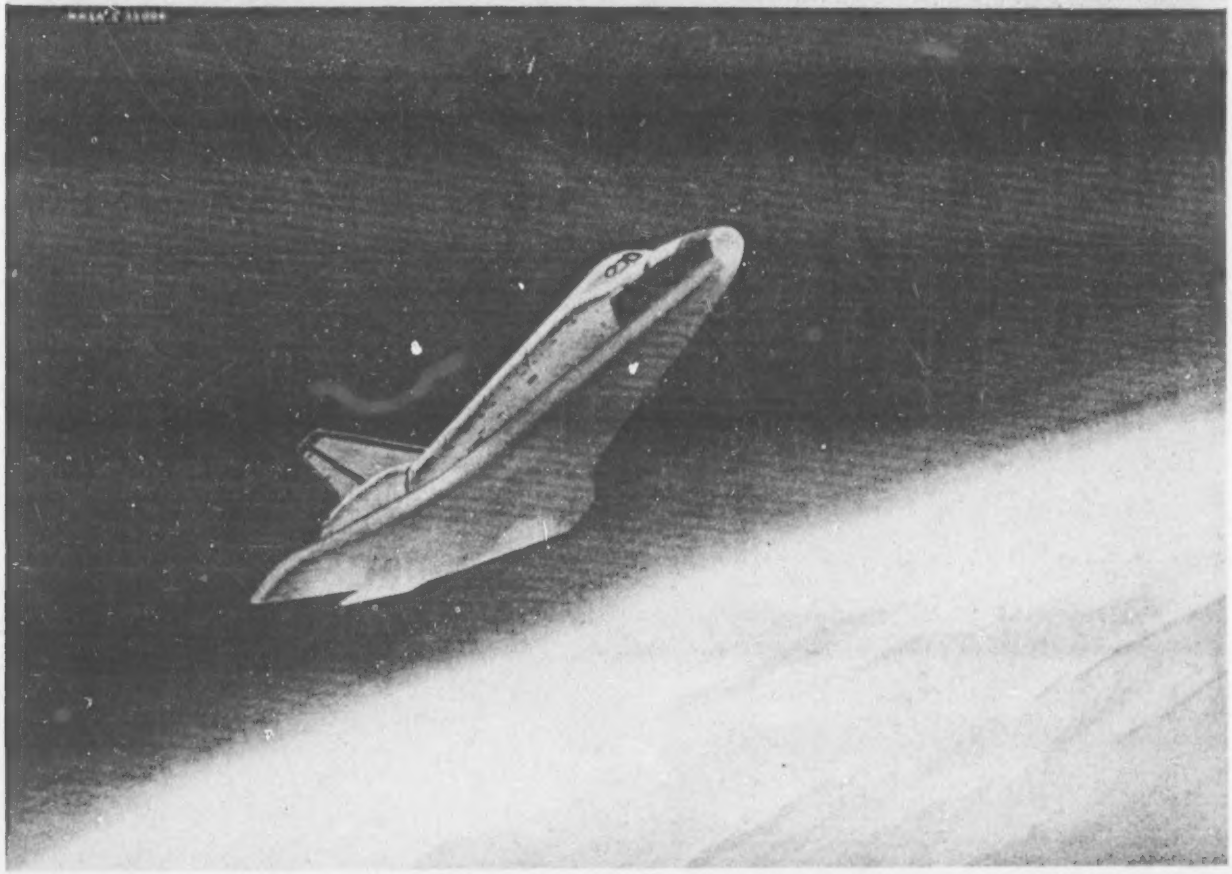

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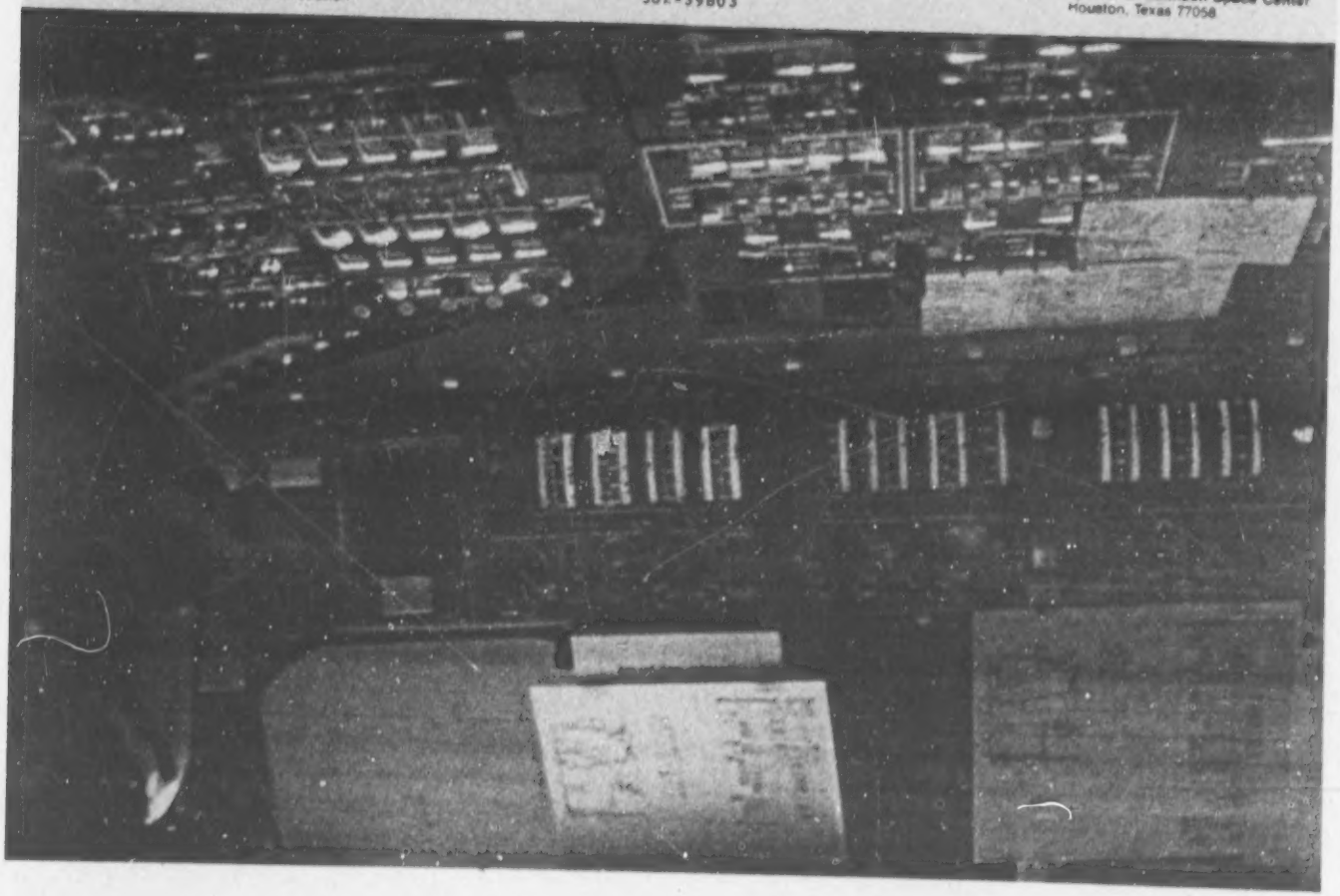

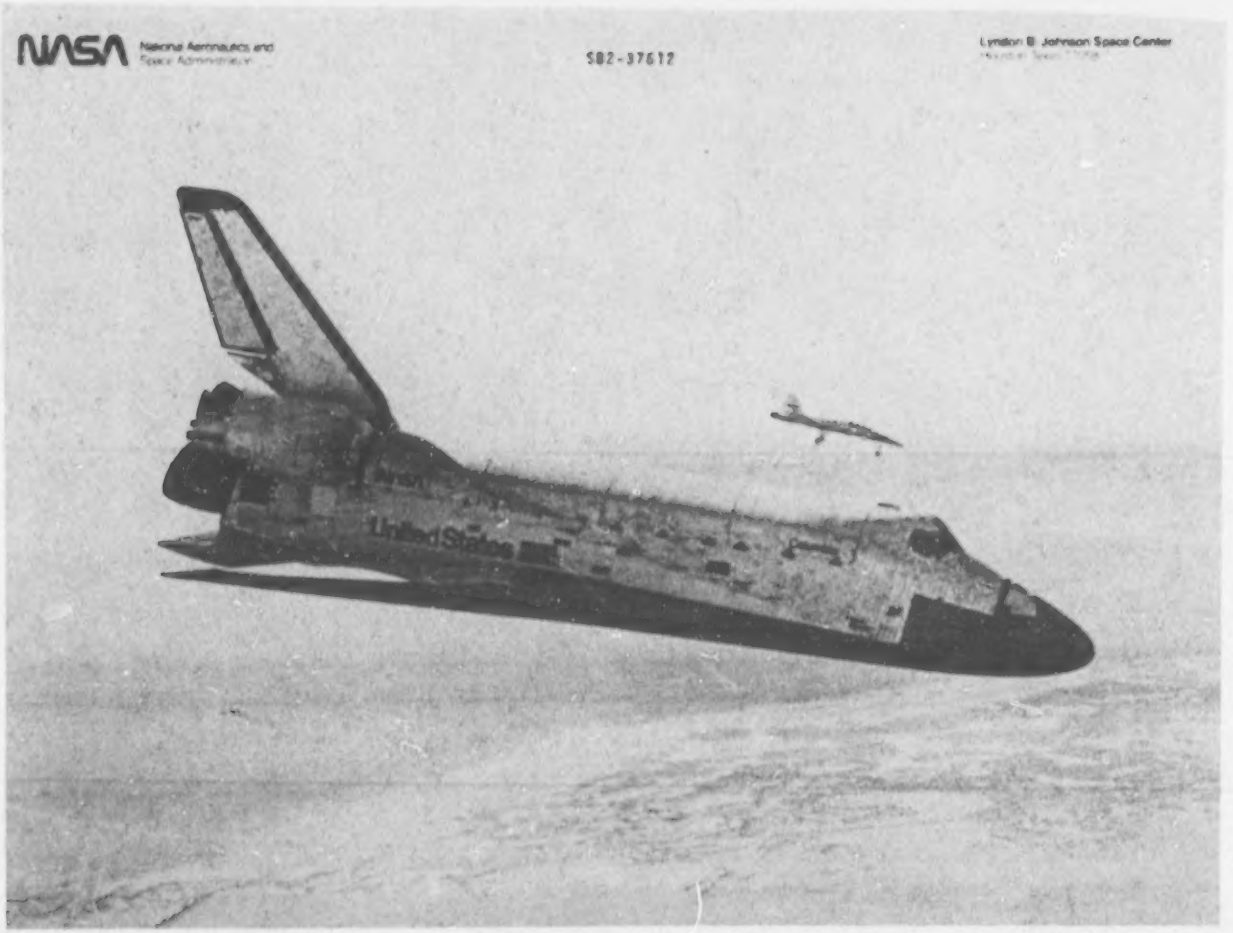
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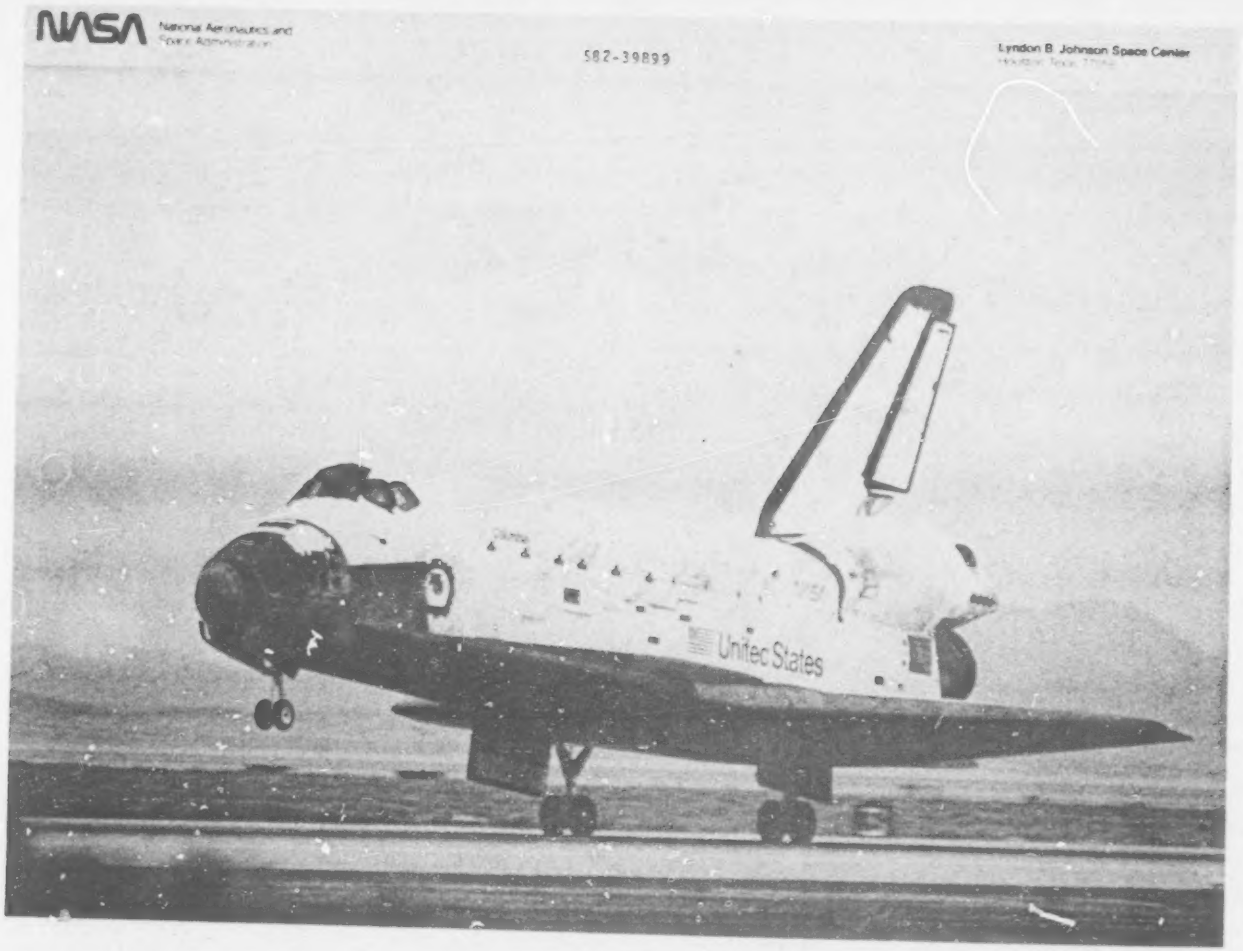
United States


NASA
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Space Administration
S82-39899
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United States

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Space Administration
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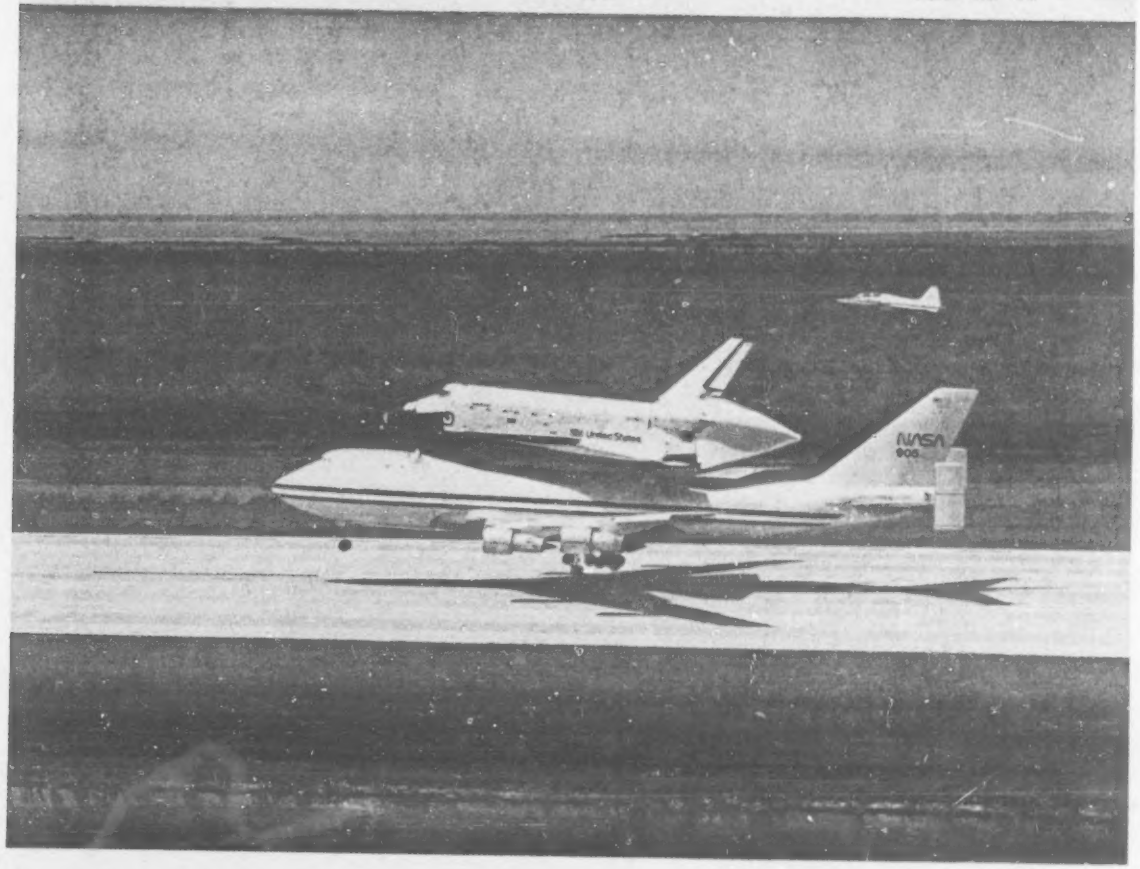


NASA-S-83-00459

SPACE SHUTTLE PROGRAM

STS 1—5

MISSION RESULTS

697

NASA-S-83-00471

SPACE SHUTTLE PROGRAM

SIGNIFICANT RESULTS OF STS-1 THROUGH STS-5

PRIMARY AREAS OF DEVELOPMENT INTEREST

- SSME - NORMAL MAINTENANCE AND INSPECTION VERY ADEQUATE FOR FLIGHT
  - LOWER VEHICLE ISP
  - HPFTP REDLINES
  - TITANIUM CHIP
- AVIONICS - EXCELLENT FLIGHT PERFORMANCE
  - PRIMARY/BFS GPC FAIL TO TRANSFER (STS-1) — PRELAUNCH
  - MEC FIXES (STS-2) — FOUND IN SAIL
  - IN-FLIGHT MAINTENANCE FOR CRT'S
  - PRIMARY GPC FAIL TO SYNCH (STS-5) — PRELAUNCH
  - BFS CONTROLLER SFP'S — PRIOR TO FLIGHT

NASA-S-83-00473

SPACE SHUTTLE PROGRAM

SIGNIFICANT RESULTS OF STS-1 THROUGH STS-5

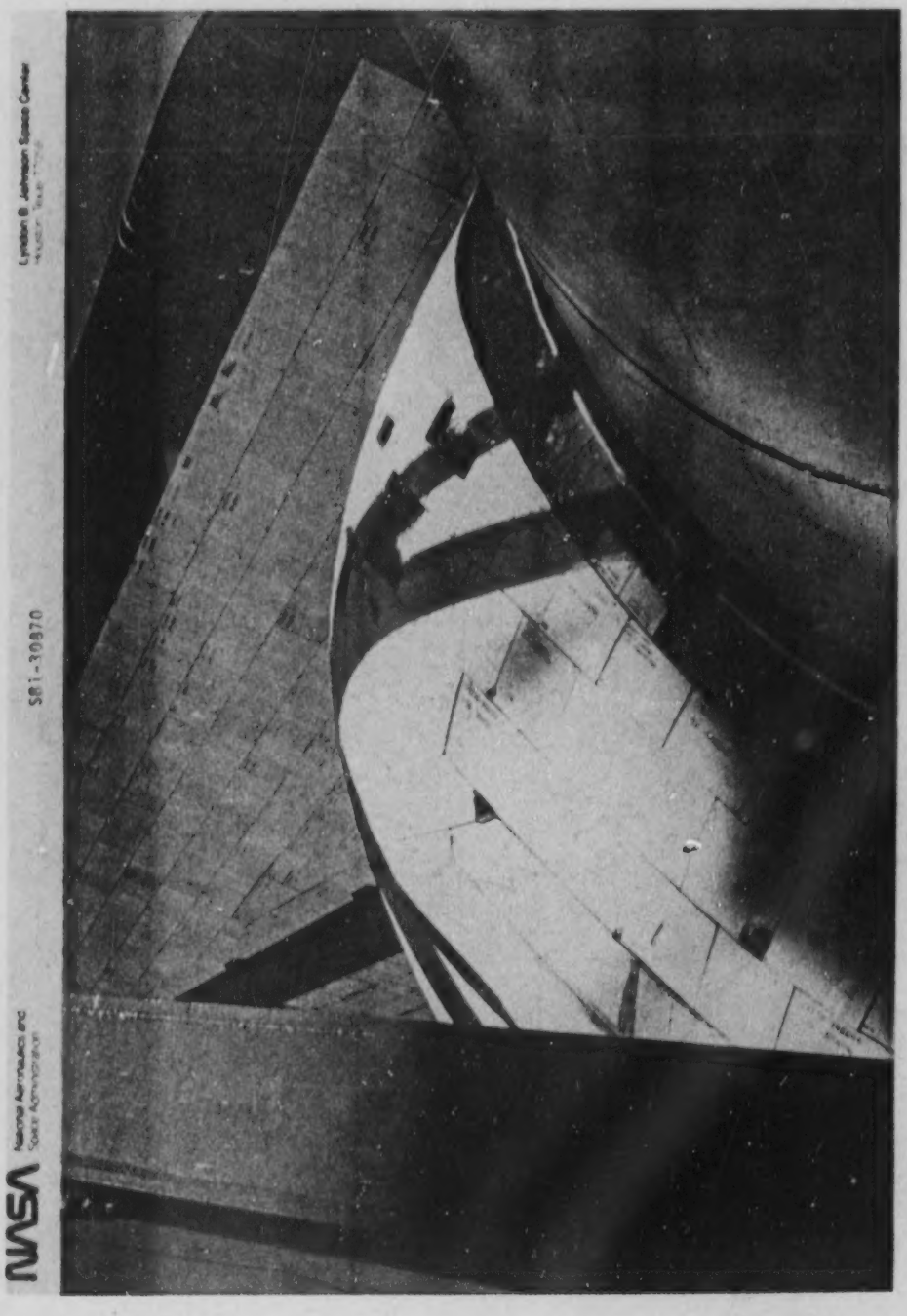
PRIMARY AREAS OF DEVELOPMENT INTEREST (CONT)

TPS

- ORBITER
  - LOST AND DAMAGED TILES
  - DECREASED EACH FLIGHT
  - EMPHASIS ON ELIMINATION OF PAD AND VEHICLE DEBRIS SOURCES
- ET
  - STS-1
    - SLA DEBONDING (FIRST TANKING TEST)
    - PROCESS IMPROVEMENTS AND CONFIDENCE TESTING

669

NASA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S81-30870

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S82-29974
Lyndon B. Johnson Space Center
Houston, Texas 77058

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S83-47222

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708

NASA-S-83-00472

SPACE SHUTTLE PROGRAM

SIGNIFICANT RESULTS OF STS-1 THROUGH STS-5

PRIMARY AREAS OF DEVELOPMENT INTEREST (CONT)

STRUCTURAL DYNAMICS

- STS-1
  - IGNITION OVERPRESSURE
  - WATER SPRAY, WATER TROUGHS
- HWT
  - LO_2 TANK OGIVE BUCKLED DURING MVGVT TANKING
    - TANKING PROCEDURE TO MAINTAIN BACK PRESSURE
  - LH_2 TANK DOME LOCALIZED BUCKLING- PRIOR TO FLIGHT
    - STRUT PRELOAD
  - BOTH FIXED FOR LWT

704

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SPACE SHUTTLE PROGRAM

SIGNIFICANT RESULTS OF STS-1 THROUGH STS-5

PRIMARY AREAS OF OPERATIONS INTEREST

CUSTOMERS

- MAJOR
  - COMMERCIAL SATELLITES
    - SBS/TELESAT
    - HUGHES/MDAC
  - CFES (WOULD NOT BE FLOWN ON ELV)
  - DOD 82-1
  - GSFC OSS-1
  - JSC OSTA-1
- MINOR
  - EEVT
  - MLR
  - GAS
  - STUDENT EXPERIMENTS
  - SAS EXPERIMENTS

NASA-S-83-00467

SPACE SHUTTLE PROGRAM

SIGNIFICANT RESULTS OF STS-1 THROUGH STS-5

PRIMARY AREAS OF OPERATIONS INTEREST (CONT)

- OTHER EVENTS
  - RMS PERFORMANCE VERIFIED
  - MOVE TO NORTHRUP STRIP
  - WEATHER EXTENSION
  - HAIL DAMAGE
  - SRB RECOVERY SYSTEM
  - EMU FAILURES
- SYSTEM
  - STS-4 AND STS-5 ON TIME LAUNCH
  - PAYLOAD DEPLOYMENTS ON TIME
  - "NEVER GOT BEHIND" (STS-5 CREW DEBRIEF)
- MATURITY OF TEAMS
  - EXCELLENT AND IMPROVING

NASA-S-83-00460

SPACE SHUTTLE PROGRAM

STS-6

MISSION STATUS

708

NASA-S-83-00468

SPACE SHUTTLE PROGRAM

STS-6 PERSPECTIVE

STS-6 IS FIRST "REAL" OPERATIONAL BASELINE INCLUDING:

ORBITER — OV-099

- **APPROXIMATELY 4400 LBS LIGHTER THAN OV-102 BASIC**
- **UPGRADED STRUCTURE AND SUBSYSTEMS**
- **EJECTION SEATS REPLACED BY OPERATIONAL SEATS**

EXTERNAL TANK — FIRST LIGHTWEIGHT TANK

- **APPROXIMATELY 8000 POUND WEIGHT REDUCTION (FROM BASIC OFT DESIGN)**

SOLID ROCKET BOOSTER — LIGHTWEIGHT CASES

- **APPROXIMATELY 4000 POUNDS PER SRB LIGHTER THAN HEAVYWEIGHT CASES**

SSME — FPL CONFIGURATION ENGINES

- **ALL MAJOR COMPONENTS HAVE BEEN IMPROVED**
- **UPGRADED SOFTWARE**

KSC

- **FIRST USE OF OPF-2**
- **FIRST USE OF MLP-2**

NASA-S-83-00469

SPACE SHUTTLE PROGRAM

STS-6 PERSPECTIVE (CONT)

- VEHICLE CONFIGURATION REVIEW (VCR)
  - SEPTEMBER 1982
  - OFT—TO—STS-6 HW/SW CONFIGURATION DIFFERENCES REVIEWED
  - CHAIRED BY ASSOCIATE ADMINISTRATOR FOR STS
- VCR SUMMARY AND SIGNIFICANT CHANGES SINCE VCR
- RESOLUTION OF STS-6 HYDROGEN LEAK

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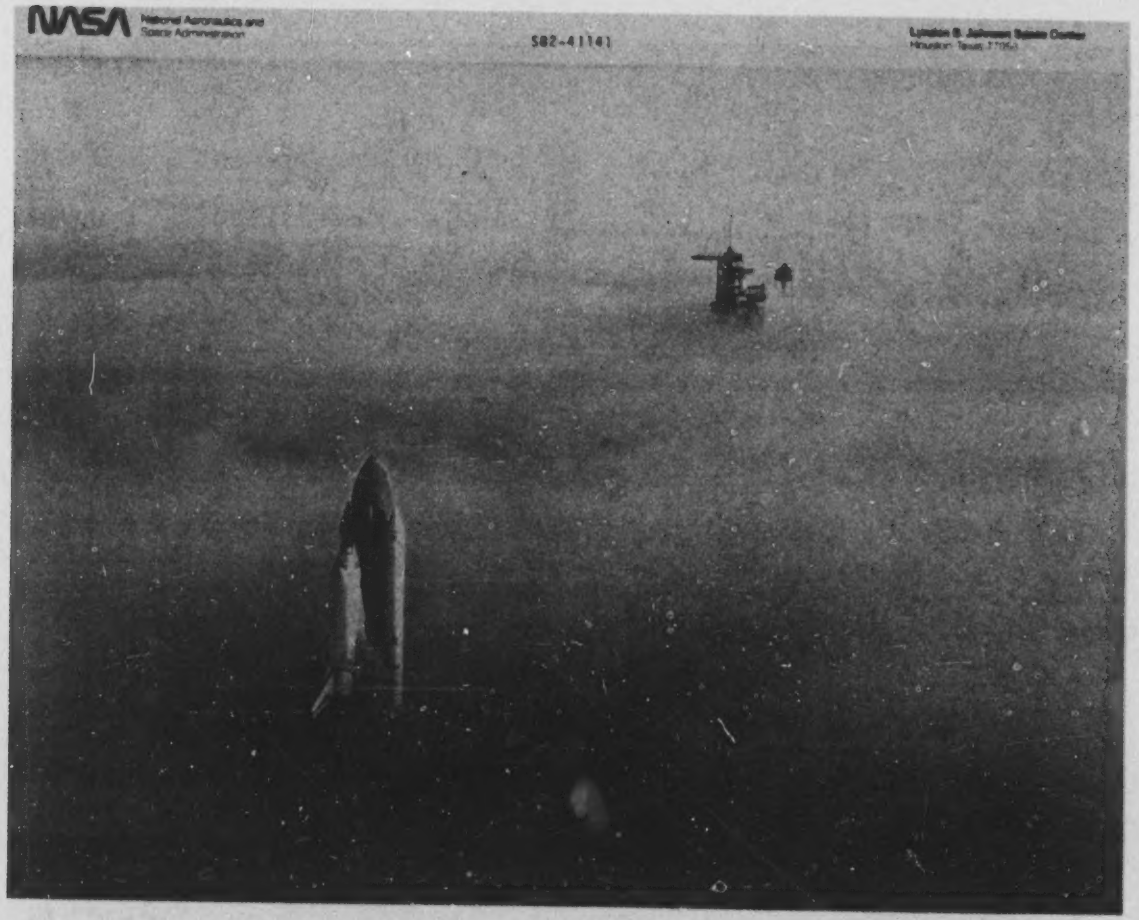
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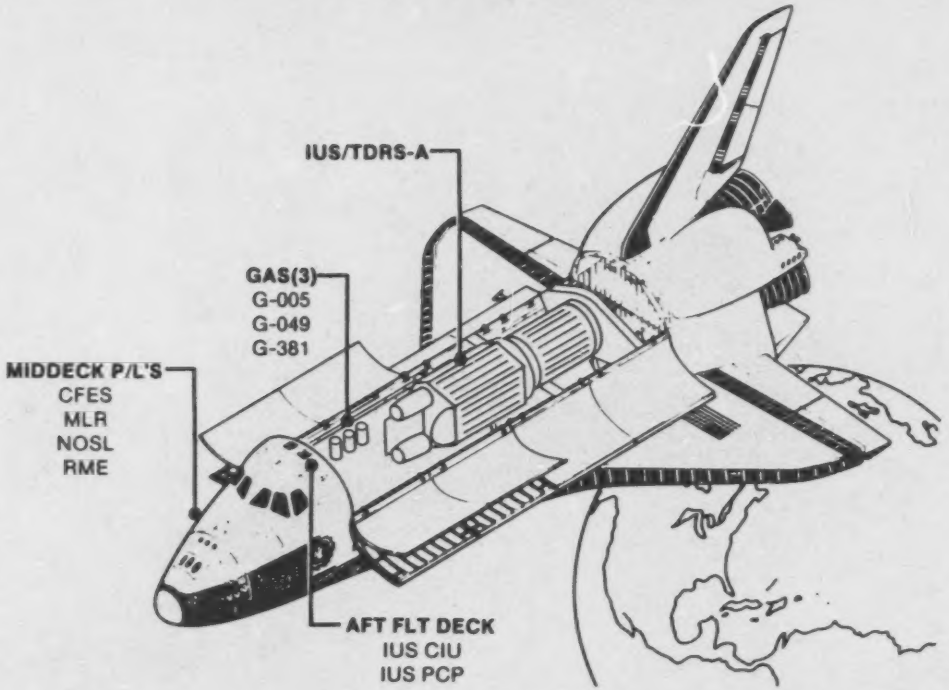
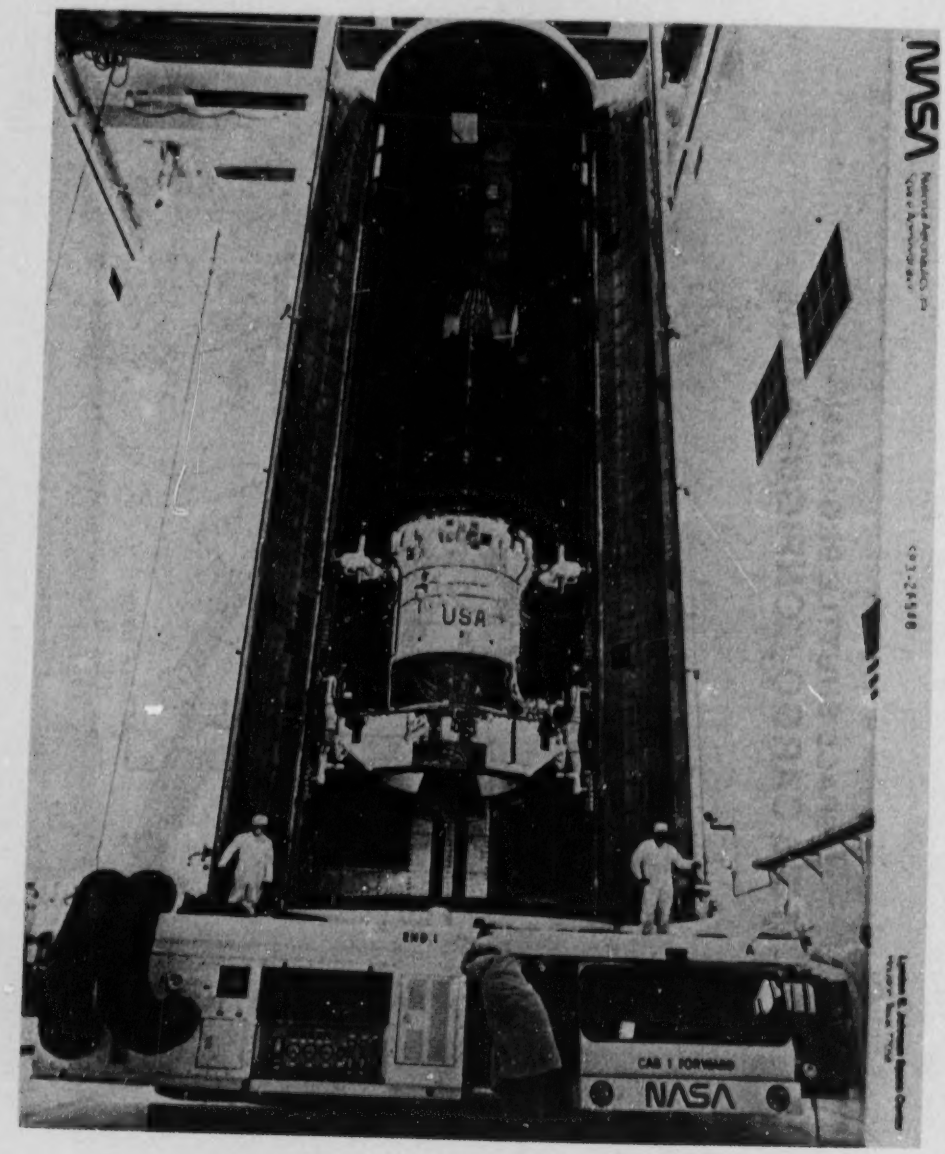
Lyndon B. Johnson Space Center
Houston, Texas, 77058

NASA-S-82-10631

SPACE SHUTTLE PROGRAM
STS-6 CARGO CONFIGURATION




USA
END 1
CAB 1 FORWARD
NASA
NASA

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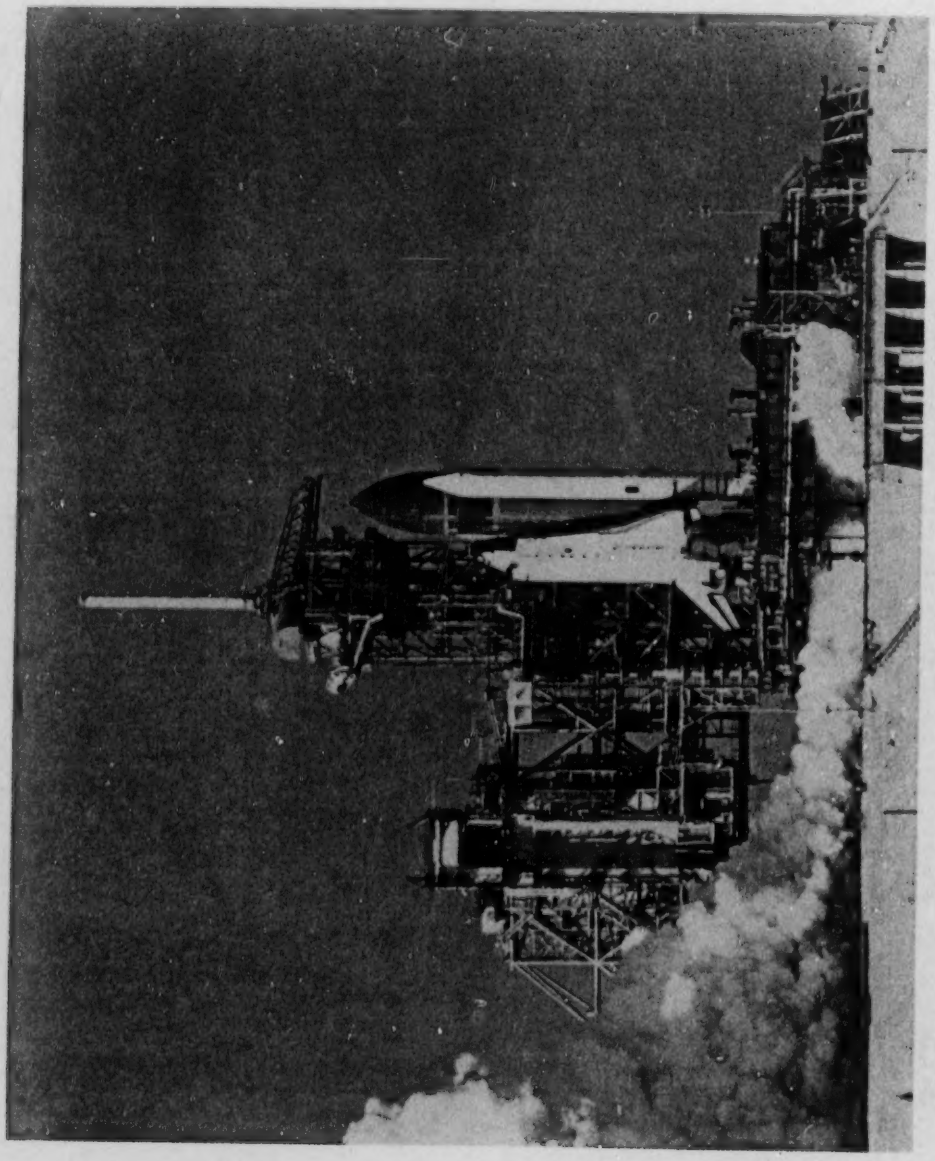
S82-41152



NASA-S-83-00480

19-505 O—83—46

SPACE SHUTTLE PROGRAM

SYSTEM INTEGRATION
STS-6 HYDROGEN LEAK

- CHALLENGER FRF CONDUCTED 12/18/82
  - VEHICLE PERFORMANCE NOMINAL
  - HIGH H_2 CONCENTRATION IN AFT COMPARTMENT ($\simeq$125 000 SCIM) DETECTED DURING FIRING
- EXHAUSTIVE POST-TEST LEAK CHECKS CONDUCTED AT 25 psi HELIUM
  - NO SSME LEAKS LOCATED INTERNALLY
  - SSME #3 HAD EXTERNAL NOZZLE TUBE LEAK
- DECISION MADE TO CONDUCT SECOND CHALLENGER FRF
  - OBJECTIVES
    - PROVE LEAK NOT INTERNAL
    - ISOLATE SOURCE IF INTERNAL
- ADDITIONAL INSTRUMENTATION
  - 17 GH_2 SENSORS (13 INTERNAL)
  - SIX BOTTLES (4 INTERNAL) — 12 TOTAL
  - 9 ΔP SENSORS, STRAIN GAGES, CAMERAS, ETC.

NASA-S-83-00479

SPACE SHUTTLE PROGRAM

SYSTEM INTEGRATION
STS-6 HYDROGEN LEAK (CONT)

- DURING SECOND FRF, HIGH H_2 CONCENTRATION DETECTED INTERNAL
  - ISOLATED TO SSME #1
  - SUBSEQUENT LOW-PRESSURE LEAK CHECKS FOUND CRACK IN MAIN COMBUSTION CHAMBER
- ENGINE REMOVED — FAILURE ANALYSIS CONCLUDED THAT THE SSME #1 LEAK ACCOUNTED FOR MEASURED H_2 CONCENTRATION
- REPLACEMENT SSME (2016)
  - PRE-INSTALLATION LEAK CHECK DETECTED LEAK IN LO_2 HEAT EXCHANGER
  - FAILURE ANALYSIS ON-GOING

NASA-S-83-00478

SPACE SHUTTLE PROGRAM

SYSTEM INTEGRATION
STS-6 HYDROGEN LEAK (CONC)

- REPLACEMENT SSME (2017)
  - FINAL ACCEPTANCE FIRING ON 2/15/83
  - UNDERGOING INSPECTION AND POST-TEST LEAK CHECKS AT NSTL
  - TO BE ON-DOCK AT KSC $\simeq$ 2/27/83
- STS-6 LAUNCH TO BE NO EARLIER THAN 3/19/83
- COLUMBIA SSME (2007) ON-DOCK AT KSC ON 2/21/83 AS POTENTIAL BACKUP

NASA-S-83-00461

SPACE SHUTTLE PROGRAM

FUTURE MISSION PLANNING

720

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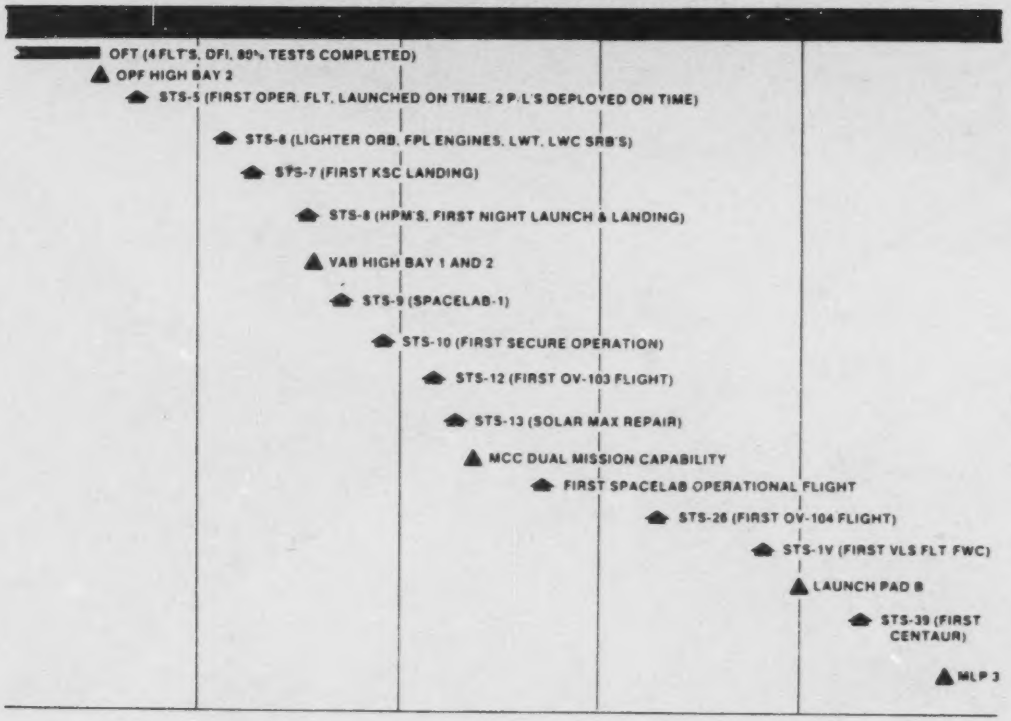
NASA-S-83-00124A

EVOLUTION OF THE SPACE TRANSPORTATION SYSTEM


OFT (4 FLT'S, DFI, 80% TESTS COMPLETED)
OPF HIGH BAY 2
STS-5 (FIRST OPER. FLT, LAUNCHED ON TIME, 2 P/L'S DEPLOYED ON TIME)
STS-6 (LIGHTER ORB, FPL ENGINES, LWT, LWC SRB'S)
STS-7 (FIRST KSC LANDING)
STS-8 (HPM'S, FIRST NIGHT LAUNCH & LANDING)
VAB HIGH BAY 1 AND 2
STS-9 (SPACELAB-1)
STS-10 (FIRST SECURE OPERATION)
STS-12 (FIRST OV-103 FLIGHT)
STS-13 (SOLAR MAX REPAIR)
MCC DUAL MISSION CAPABILITY
FIRST SPACELAB OPERATIONAL FLIGHT
STS-26 (FIRST OV-104 FLIGHT)
STS-1V (FIRST VLS FLT FWC)
LAUNCH PAD B
STS-39 (FIRST CENTAUR)
MLP 3

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592-33419
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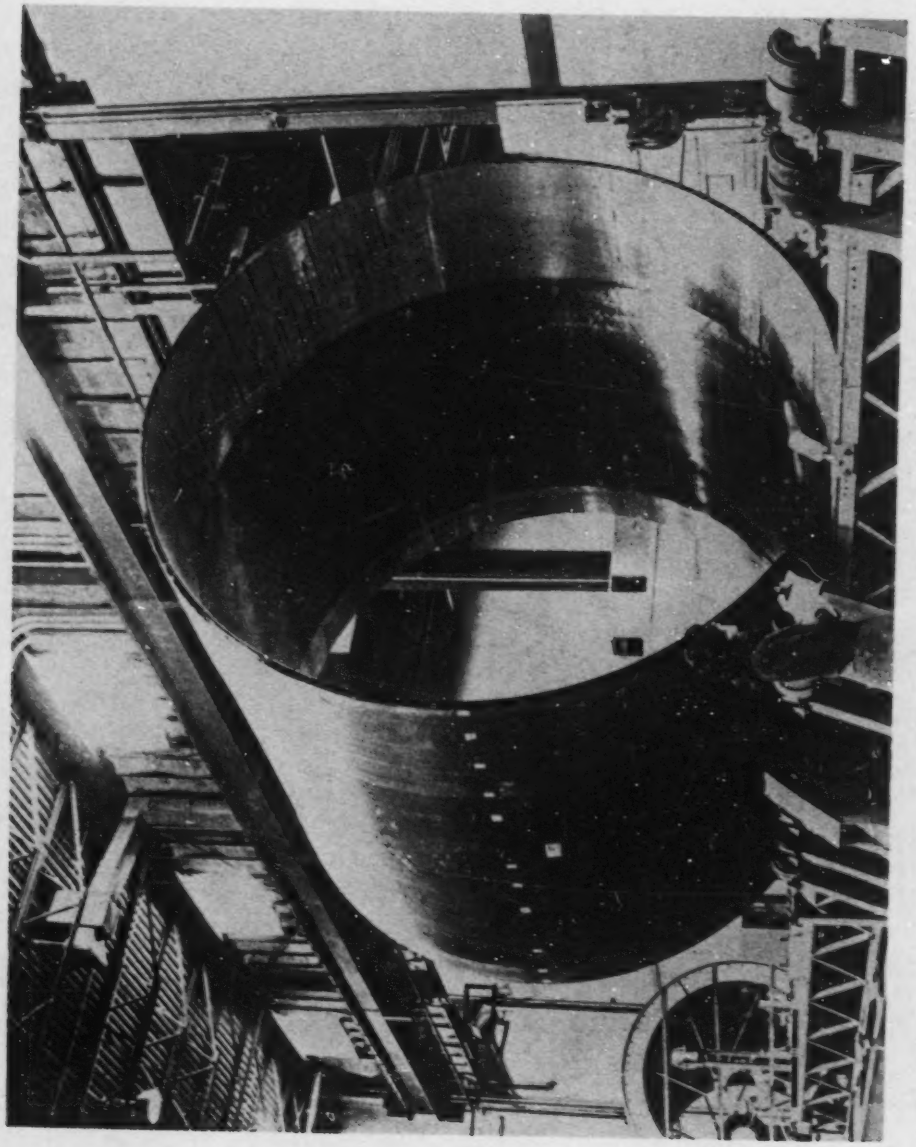
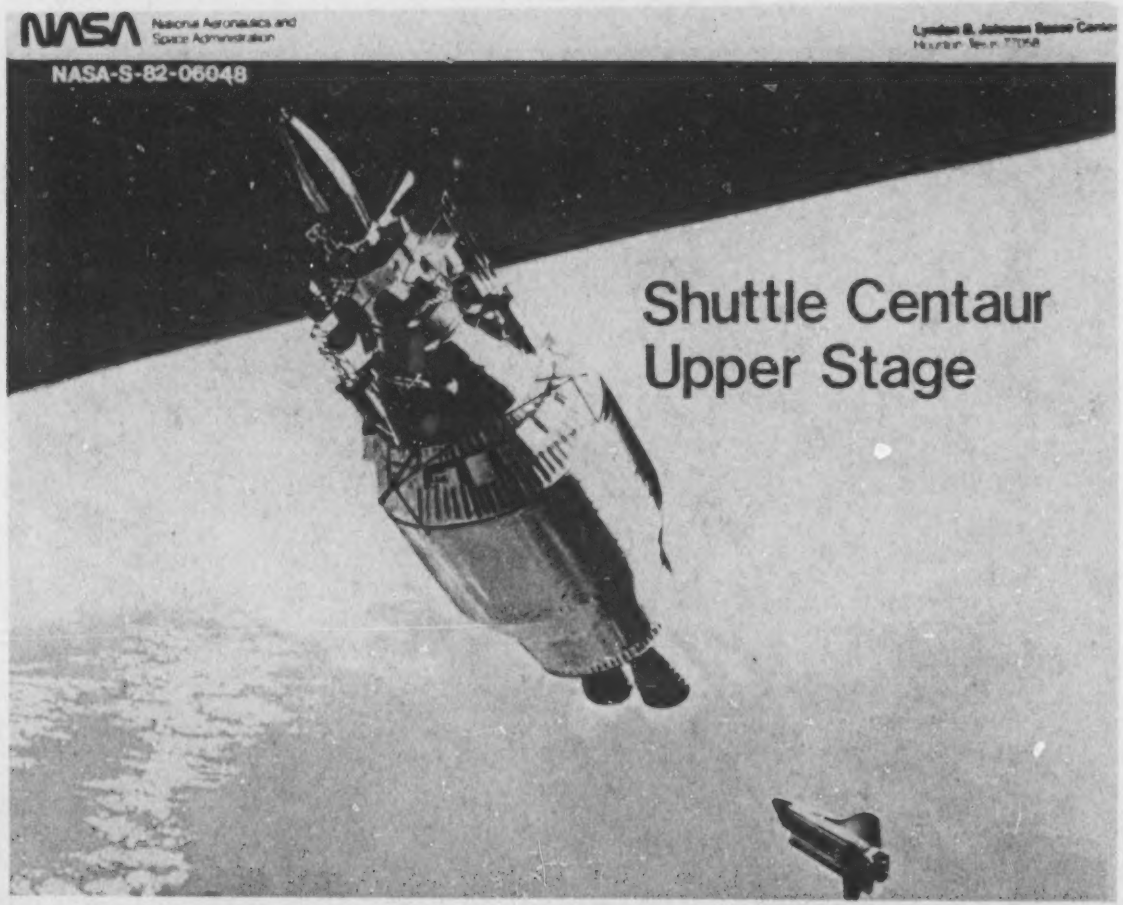
Charles O. Bennett

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NASA-S-82-06048
Shuttle Centaur
Upper Stage

Mr. MOSER. To put ourselves in the organizational posture one more time, the orbiter project reports to Jerry Griffin. I'm the deputy, as Jerry said, and Arnie Aldrich is the manager for the project. Programmatically, the shuttle program has four elements: the tank, the boosters, the engines, and the orbiter; so we represent one of the four elements of the shuttle program, and our project is under Glynn. If we had one picture or a big picture to say what the orbiter project does, I guess this would represent it. Our charter was to design and develop the orbiter which we've done over the past 12 years to produce the orbiters, which I'll go into a little bit of detail on with you in a moment, where we stand on that, and to support the operations of the shuttle program and the orbiter project.

[Exhibit C-1.]

So here we are at the completion of that design, development, production, and supporting operations after we've delivered our payloads for orbit.

[Exhibit C-2.]

Just to walk you through this rather complicated vehicle real quickly and try to simplify it for you, the crew and all the controls for the orbiter up in the forward end and a pressurized container is suspended within the forward fuselage itself. That's where all the environmental control system is. The payload bay or the mid fuselage is essentially just for the payload. We have some of our life support systems, our propulsion systems, hydraulic components in the payload bay. The payload bay doors have its radiators to control the temperature of both the payloads and the orbiter itself. In the aft end of the vehicle is essentially the propulsion system of the orbiter. We ahve three main engines back here, which is one of the other elements of the program, about 500,000 pounds of thrust for each one of those engines for a total of 1½ million pounds of thrust coming through the base of the orbiter. Then, as Glynn pointed out, the orbiter maneuvering system, the OMS PODS are back here. To give you some perspective of those elements, they're about the same size as the service module on Apollo or a little bit larger than the command module. They each have a main engine or an OMS engine on those which deliver about 6,000 pounds of thrust; so we've gone from 500,000 down to 6,000; and then we have 38 small engines here which produce about 870 pounds of thrust. These are Vernier maneuvering systems, and then we have 24-pound thrust engines which we have—our rockets which we have four—six of those, which then are for flying attitude adjustments. So we go down from a macro scale down to a microscale to control on orbit as we need.

Chairman VOLKMER. What type of fuel do these engines use?

Mr. MOSER. It's a hypergolic fuel, MMH N204.

Congressman LUJAN. Gas, liquid?

Mr. MOSER. Liquid, everything is liquid.

Chairman VOLKMER. Would you say a basic liquid nitrogen or what?

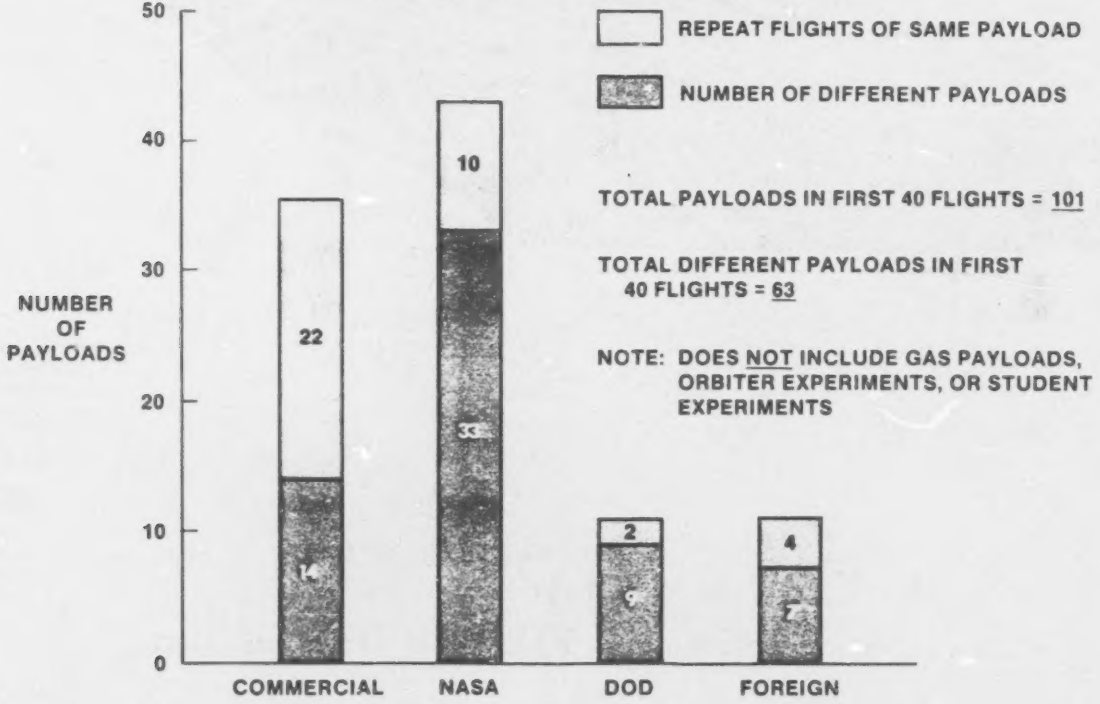
Mr. COVINGTON. It's a liquid at room temperature and they ignite when they mix. You don't have to ignite. That's what hypergolic means.

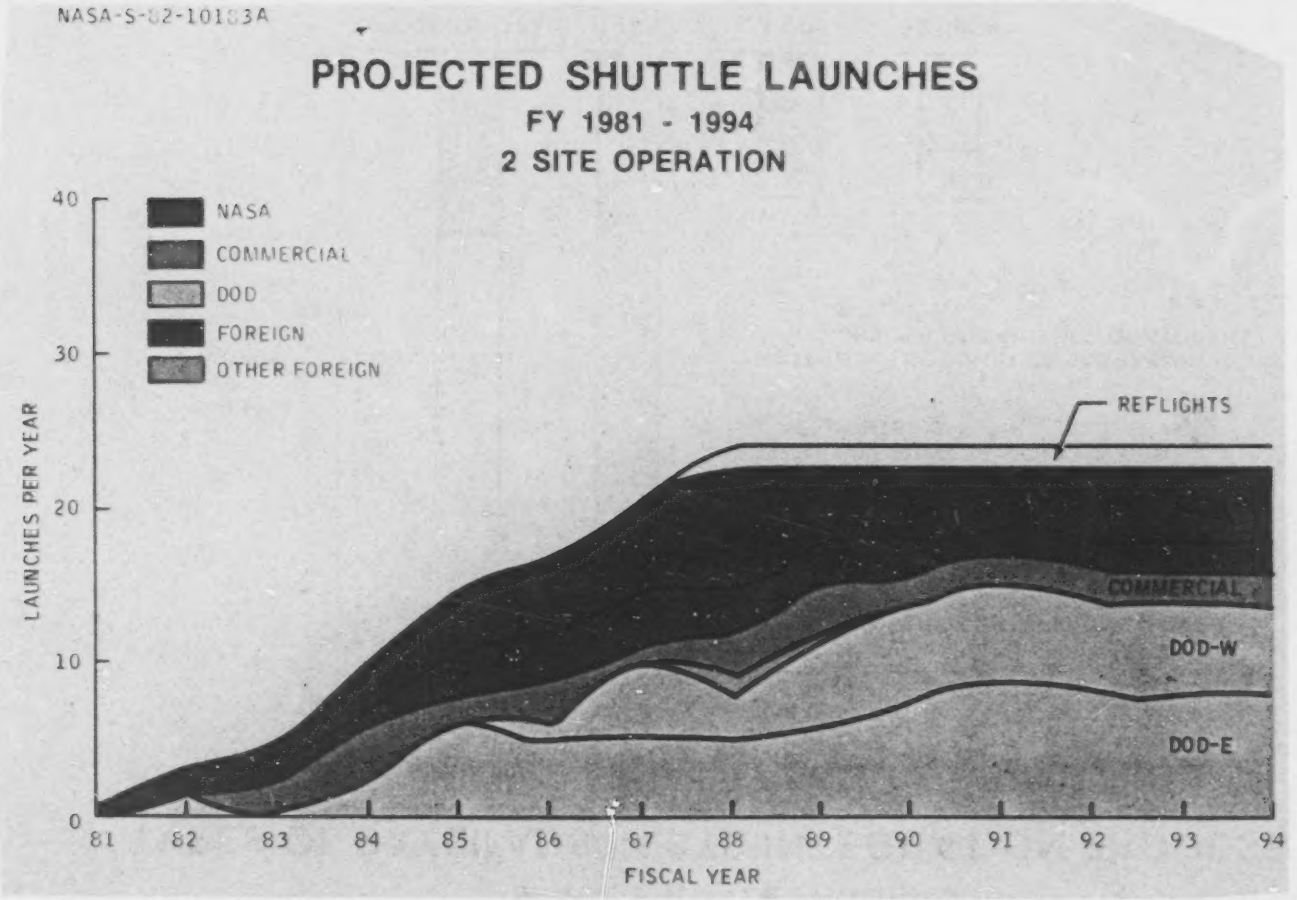
NASA-S-83-00474

SPACE SHUTTLE PROGRAM

TYPES OF PAYLOADS IN STS INTEGRATION PROCESS

13000-8 MANIFEST (NOV 82)
FIRST 40 FLIGHTS




NASA-S-82-10103A
PROJECTED SHUTTLE LAUNCHES
FY 1981 - 1994
2 SITE OPERATION
NASA
COMMERCIAL
DOD
FOREIGN
OTHER FOREIGN
REFLIGHTS
COMMERCIAL
DOD-W
DOD-E
LAUNCHES PER YEAR
0
10
20
30
40
81
82
83
84
85
86
87
88
89
90
91
92
93
94
FISCAL YEAR

NASA-S-83-00463

SPACE SHUTTLE PROGRAM

NASA/AF RELATIONSHIP

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Houston, Texas 77058

NASA-S-83-00117

SPACE SHUTTLE PROGRAM

NASA/AF RELATIONSHIP

- ORGANIZATION
- BUDGET
- VANDENBERG LAUNCH SITE
- PAYLOADS
- IUS/CENTAUR
- CSOC
- SECURITY

NASA-S-83-00464

SPACE SHUTTLE PROGRAM

PERSPECTIVE FOR THE FUTURE

781

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NASA-S-83-00104

SPACE SHUTTLE PROGRAM

PERSPECTIVE FOR THE FUTURE

- SYSTEM WORKS
  - HARDWARE/SOFTWARE/PEOPLE
- RISK MANAGEMENT CONTINUES TO BE PRIMARY TASK
  - NO FAILURES
- EVOLUTION OF OPERATIONS MANAGEMENT WITH HIGH FLIGHT RATE, FEW ORBITERS
  - TOOLS/TECHNIQUES/DELEGATIONS/ETC
- QUALITY IN PRODUCTION ENVIRONMENT
  - REDUCTION OF OPERATING COSTS
  - IMPROVEMENT OF THE PRODUCT
- INFORMATION SYSTEMS VS SECURITY
- MAINTAIN OPTIONS FOR FUTURE OF STS OPERATIONS
- NEED FOR NEW START

Mr. GRIFFIN. It's nitrogen tetroxide, a very toxic oxidizer in MMH, monomethylhydrozine, is the fuel. The hypergolic nature, you just put them together and they go. They're both pretty toxic, so you have to be very careful. You'll see people in what we call SCAPE suits dealing with those systems.

Mr. MOSER. So to repeat: fuel MMH oxidizer into a hole mixing together without any ignition source; that's the hypergolic reaction. See, all the propulsion systems are liquid with the exception of in the shuttle of the solid rockets itself, which is a solid rocket propellant.

Talking about the structure just basically, when we developed the shuttle, we tried to minimize the state of the art development overall in the program. The shuttle itself is an aluminium air frame, much like the aircraft that you flew down here on. The only advancement that we really made as far as industry-wise was the payload bay doors and the OMS POD structure itself which is a graphite appoxy which now, of course, almost all aircraft are going to the composites. It essentially gives us like about a 25-percent reduction in the weight of an airframe over that of an aluminium. The other state of the art development in the orbiter project were only two; the computers and avionic systems which control the vehicle, provides its intelligence, and the thermal protection systems. [Exhibit C-3.]

Let me highlight that to you right here. The thermal protection system in black are the tiles which you've heard about. On Columbia, there were about 31,000 of these tiles. It's a material of density of about equivalent to balsa wood. In this specimen, I'll show you here, it's loaded to an aluminium structure much thicker than that of the aluminium with a felt material, which isolates this very low strength glass material from the aluminium structure so that the aluminium can expand and contract without breaking the glass. It's then coated with glass coating. So this protects the orbiter in the range of about 2,000 degrees Fahrenheit. It's fully reusable. It's susceptible to damage as you can see on the surface of that where it's been penetrated. But as we fly it, it is performing as good or better than we anticipated. On the upper side, the lee side—as the orbiter comes back typically at about a 40-degree angle of attack, it's experiencing temperatures on the bottom somewhere in the 2,000-degree range. Up in the leading edge of the orbiter, along the wings and the nose cap, we have a carbonous rayon material which can go up to about 3,000 degrees, all fully reusable.

We saw on Gemini, Mercury, and Apollo, we had a material which would literally go from a solid to a gas in ablator and that absorbed the energy. We do not have to replace those, other than through flight damage or gound handling damage. It's our own protection system on the orbiter.

As the vehicle enters, the top side of the vehicle is cooler. We then get a hot steak along here which we have a white tile, basically of the same material that you see here in the high temperature reuse area in protecting itself in about the 1,000, 1,200 degree range. Then from here we go into a much simpler material. On Columbia, we literally used felt—the same thing that Stetson hats are made out of—just not needled quite as much. Put a rubber coating

over it, and that protects us up to about 750 degrees. We've essentially protected everything on the vehicle.

I'll show you in a moment where we're changing out part of the insulation——

Chairman VOLKMER. Does this cover all of the rest of the outside surface?

Mr. MOSER. Yes; so what you see there is the area that is in white. That is called FRSI, flexible reusable surface insulations. We're working that up to about 750 degrees.

You can see in the thickness of that and the way the tiles are sculptured in their thickness, when you're coming back with 3,000 degrees in this region here up here and a couple of thousand degrees here, we're protecting our aluminium down to 350 degrees. Then once you get inside the cabin, down to a shirt sleeve environment there. So we go through quite an extreme environment in protection on a vehicle.

Glynn has gone through about most of the programatic aspects. What we've done in the shuttle—in the orbiter project as far as our test objectives, we have literally completed our development. We have some residual development which I will touch on briefly at the end of the presentation. We're primarily now in the production phase of our project, and that's where our main thrust is. Rockwell International out in Downey, Calif., is our prime contractor. This year, we and the orbiter project itself are representative of about $750 million worth of work to Rockwell to produce our orbiters and to support our operations. That also includes support to Vandenberg, as Glynn pointed out, and to the JSC support for operations.

[Exhibit C-4.]

Our current status on the next orbiter which is 103 or Discovery. Out of four, we've got two in the field, as Glynn showed you. The next one is delivered in September of this year. It is on schedule. I'll show you some detail of the schedules on that momentarily. We are scheduled for power on next week, and we are essentially on that schedule. Everything is at Palmdale. It is being assembled north of Los Angeles in the Palmdale, Calif. area.

[Exhibit C-5.]

This is the top view of an orbiter. We have two stations in Palmdale for which to assemble the major components of the vehicle. This shows from the far fuselage aft, the payload bay open here—the payload bay door's not on in this position. We have our forward thruster compartment, our reaction control system module which gets installed here. The crew cabin particle stabilizer is not installed at this point.

[Exhibit C-6.]

This is the body flap. This is a trim surface for the orbiter, much like a trim on a high performance boat. It trims the attitude for the vehicle during entry, and then any additional trim and maneuvering is affected through the torque box.

[Exhibit C-7.]

The out-of-station work, if you will, is the major assembly of the installation of the tiles on the orbiter. Some of our thickest tiles are in this region, about 4 inches thick. They go down in thickness now to about a half-inch, depending on the temperature which they experience. So the procedure is to get the body flap complete with

the tiles installed on it, bringing it up and mate it to the orbiter which is going to happen about the first part of March, and then go through the system checkout on it.

[Exhibit C-8.]

On the next vehicle, we have modified the thermal protection system somewhat in the lower temperature regions. As you can see from the tile material itself, it's a very brittle material.

[Exhibit C-9.]

So what we've done is we've replaced some of the half-inch thick type tiles with another material. It's a glass type material. It's called AFRSI, it's just an advanced flexible reusable surface insulation or blanket. We're installing a large area of those blankets on the vehicle right now. It's really, in light of what you were saying, looking at the turnaround, trying to bring that down. We could see that these white tiles were causing us some problem in the turnaround cost and time. So with the enhancement of the TPS system, these blankets work with more durability in the system. That's one of the major differences between *Discovery* and *Challenger* and *Columbia.*

[Exhibit C-10.]

This is just showing you some of the—this is the forward RCS system, the reaction control system, with the extensive amount of plumbing that it has for the forward thrusters.

[Exhibit C-11.]

Then of the roughly 22,000 tiles that we have to install on this vehicle, we've got at large majority of those already installed.

This is looking at the bottom end of the vehicle. It gives you some feel for the size here. These are roughly 6-inch by 6-inch tiles. They have a step and gap requirements as they are installed so for smoothness, for aerodynamics, and also for heating between the tiles.

But you can see after these individual tiles are installed to the required specification, it gives you a pretty smooth surface.

[Exhibit C-12.]

We're pretty proud of what—in the production phase of what we've done on this. I think the whole country is looking at productivity and improvements of productivity. We are essentially on an 85-percent learning curve for our vehicles, which we're producing an orbiter for about 85 percent of the effort of what a previous orbiter was produced. We've maintained that. We've made a lot of strides between the second and third orbiters, and we hope to maintain the same type of improvements between the third and the fourth. We may not realize it between the third and fourth, since it's the last vehicle being flown, but we're certainly striving for that.

[Exhibit C-13]

This is a schedule on the AFRSI blanket installations. We've got about 2,200 of those blankets to install. This shows the blankets after installation on the orbiter maneuvering system itself, the OMS POD. This pod, complete with its tankage and control systems, will then be mated to the orbiter and then checked out.

[Exhibit C-14.]

104, Atlantis, is to be delivered in December 1984. It, too—most of the parts are on schedule there. We have some piece parts that

are behind. We're running about 8 weeks behind on some of that. That was not atypical for what we did on OV-99 and 103.

There are work-arounds on that that we can effect, and without modifying the overall schedule of the program. We have begun the tile fabrication at Lockheed. We have, as I said, a recovery plan in work to catch up on that. Right now we see essentially no threat of completing delivery on schedule for 103 and 104. We feel very confident that we will make both of those deliveries.

[Exhibit C-15.]

To give you an idea a little bit more of what goes into the makeup of one of these orbiters, this is the far fuselage of the orbiter starting off with typical aircraft type structure, skins and stringers. The frames are installed, the stringers like you used to make the old balsa models and put paper on them—instead of paper, we're putting 20,000 stick aluminium skin riveted in place, and once that's completed, then the systems are installed, and the vehicle is made. So it's built up in a modular concept, if you will.

[Exhibit C-16.]

The work I'm showing you here, both on the far fuselage, lower and the crew module here is done at Downey, Calif. The other major subcontractors on the vehicle, as far as the structure is concerned, the wings are made at Grumman, vertical stabilizer is made at Fairchild in Long Island, Grumman also being in Long Island. The mid fuselage is General Dynamics in San Diego. The OMS PODS are made in St. Louis. The body flap is made at the Columbia Division of Rockwell International.

[Exhibit C-17.]

This is a thrust structure. It, too, is made in Downey, Calif. This is where our three main engines attach, at these points here, develop 1½ million pounds of thrust up through the orbiter airframe and into the external tank while it's ascending.

We did this differently on 103 than we did on 102. We, essentially, completely stuffed the back end of the orbiter with all of its tanks, all its plumbing, the main propulsion system, the avionics boxes; then we took the completed assembly up to Palmdale via truck and mated it to the mid fuselage and the wings which were already there, and the system was essentially checked out as individual components, and then as a total system which will go into check next month.

[Exhibit C-18.]

The other activity we have underway is Columbia, which is currently at the cape now—let me back up one step on that. The difference between the first orbiter Columbia and the other three was essentially—in addition to some improvements in the controls and the crew-related aspects, as Glynn pointed out, we configured it for a flight test article. In so doing, we had ejection seats in there; we had about 3,000 channels of instrumentation for temperature and accelerometers, loads in the structure, which we made sure we knew what this vehicle was doing once it reached the full environment for flight, going from subscale to full scale.

To fly the operational flight, we need to make some modifications to it. We have got to pull the ejection seats out; we've got to pull the instrumentation out, and configure it for an operational vehicle.

There's one interim step in there. We're configuring it to fly the spacelab mission on STS-9, and in so doing, we're making just those modifications required to accommodate the spacelab payload. We're leaving some of the crew's equipment in there like it was on the development plat with the ejection seats in, but they're deactivated. We will in this case be flying a crew of six, and George will probably get into that a little bit with you. So we've gone from Gemini, two, and Mercury, one, up to a crew of six on STS-9.

We're on schedule and this work is to be completed to support a launch September 30, 1983.

[Exhibit C-19.]

We do have some limitations on this vehicle. Columbia and the whole orbiter evolved like any aircraft program or spacecraft program does; as you design it and develop it, you learn more about it. We've got some restrictions on this spacecraft as far as its maneuvering capability. We just can't turn it quite as tight as we can on other orbiters; and when we land, we're going to land just a little bit softer. It doesn't have all the structural beef-ups that the remaining three orbiters have.

Mr. GRIFFIN. Excuse me. The acronym SLO doesn't mean we're dragging our feet. That's "spacelab only."

Chairman VOLKMER. Why does this not have all of the things that you're talking about?

Mr. MOSER. Well, this structure was essentially designed in 1975. As we understood the dynamics of this total launch configuration, we had another SLO cycle, let me say, or another SLO analysis in 1978. At this time, this vehicle was too far along on the production line to catch it, and we essentially had to beef up in the mid-fuselage region—right up in here we had to beef up our skin slightly. It was the primary modification for the structure. The tiles were another thing. We had to beef up the skin in some areas because of the structure deflecting underneath the tiles; it tends to pop them off. So we understood better the thermal environment which the vehicle was living in. Simply, again, an energy process.

Mr. GRIFFIN. A little bit like a prototype in a fighter in the aircraft line. Some of the earlier vehicles, you learn something in the design process that you catch on a later bird.

Chairman VOLKMER. Three and four are less prototypes, then?

Mr. GRIFFIN. Yes.

Mr. MOSER. Absolutely, we took advantage—and, again, on the third and fourth ones, with our flight experience, our better understanding of the environment which the orbiter has to live in, we even scraped a little bit of additional weight out of those units compared to the second one, another couple of thousand pounds. So it's those kinds of things. If you look at one vehicle and compare it to the other, you couldn't see it.

Probably even stripping everything off and looking at it you wouldn't be able to detect it. It's changing skin thicknesses, you know, a couple thousandths of an inch; but it's down to that kind of finesse.

[Exhibit C-20.]

As far as the "spacelab only" mod, we're going to increase the strength integrity of some of the tiles; again, a part of the evolution of the development of this thermal protection system material.

We found that we could simply paint a liquid on the bottom of the tiles and increase the strength by a factor of 2, which is to assure us of a greater margin for these tiles. So the second, third, and fourth vehicles have all their tiles strengthened this way, so we're going back while we've got the vehicle down and doing the under side of the vehicle just to give us that additional margin.

Some of the things that we saw on some of Glynn's pictures where we lost a few tiles, some of that was attributed to this lower strength, so we shouldn't be seeing that anymore.

[Exhibit C–21.]

Make a few changes in the mid fuselage to accommodate the payloads. Mostly instrumentation and accommodation for payload changes is not very much in the aft end of the vehicle.

The forward fuselage, we're putting the bunk-type sleep stations in there since we do have a crew of six and they'll be working in shifts. We're making some panel wiring modifications for the spacelab for moving our instrumentation, as I mentioned a while ago, which was for the development and understanding of the loads and the temperatures which we were flying in; adding a communications system, the KU-band antenna, putting in this place the CFES of McDonnell Douglas and Johnson & Johnson, attached in the same physical location as the galley. So it's just a pull-out of the galley and plug-in the CFES with some of functional hookups, but in this case we will fly the galley for the large complemented crews.

We've got a scheduled completion date on this of about toward the end of May of having this vehicle ready to get ready for the September launch.

[Exhibit C–22.]

In summary, again, when I talk about our major objectives in the orbiter project, we have delivered two; we've got two more scheduled to be delivered; we're up on our learning curve; we think we've made significant strides there in the productivity area; we see no problem in meeting that schedule. We have some residual development work not unlike the things we did between the first orbiter and the second—the 2 and 3 in changing the strength capability. We have got to prove our shuttle accident performance, as Glynn pointed out, with the boosters and the lightweight tanks; that affects the loads in the orbiter. We've got to make sure that the orbiter is capable of accommodating that' we're on schedule with that work. At Vandenberg, we're supporting both in ground supportive equipment and identifying what requirements they need to support an Orbiter there, and also looking at the launch environments and the loads there to be sure that the orbiter is compatible with that.

The other thing we have is the ground track from the Orbiter when it comes back from orbit. There is a desire, whether it's for an abort or for some landing in a desired site; we've got to maneuver in our cross range, and we still have to complete the development work on that.

So some small development work out in the next 2 or 3 years, and we'll have that complete.

Our other major activity is in logistics and spares. This is not an insignificant amount of effort, especially in terms of dollars right

now. We're laying in the spares program. We have seen—getting some feel for what we need as far as replacements and repairs on the orbiter, and it looks like we've to that part of the prgram fairly well scoped now. We're just coming up on this as far as the laying of total work, but we're on schedule.

Then our fourth area is the continued support of the operations, both here, at the cape and during the operational phase itself. That terminates my presentation.

Mr. WEEKS. I need to clarify one thing. I'm sure most people would know. You used the word that you are going up on the learning curve, when, in fact, you're really coming down.

Mr. MOSER. Coming down on the learning curve, right. We're going up on our productivity. Thank you, Mike.

Mr. GRIFFIN. Clarke Covington is the actual manager of the Space Station Project Office, and he's going to talk to us a little bit about that.

[Exhibits C-1 thru C-22 of Mr. Moser's oral presentation follows:]

ORBITER STATUS

MOSER

MR. [redacted]

Orbiter Project Office

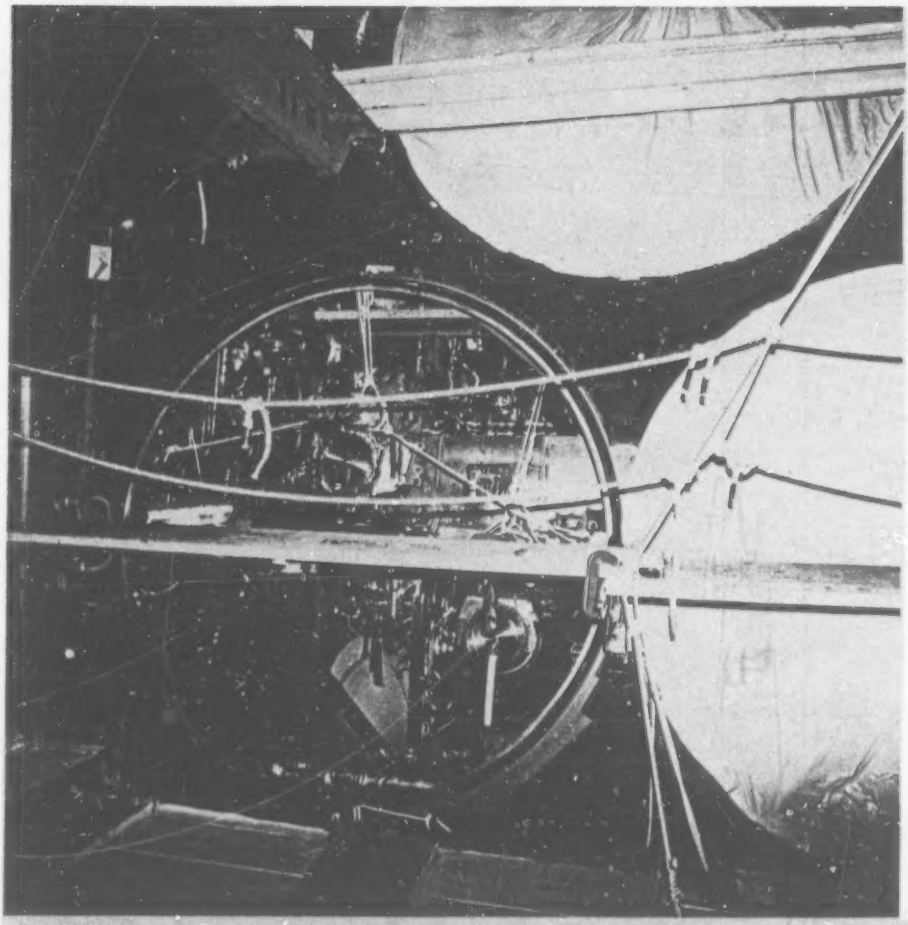
Johnson Space Center
Houston, Texas

OV-102 SLO MODS

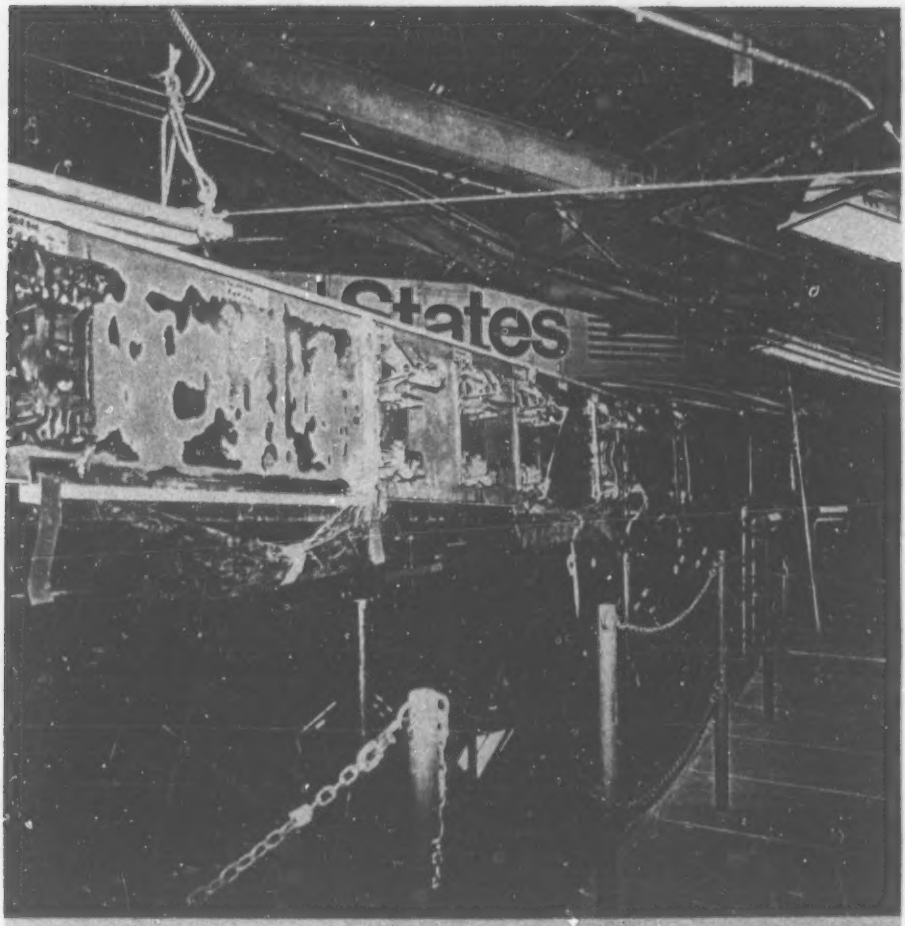
OV-102 SLO MOD

MA/A. D. ALDRICH
FEB 25, 1983

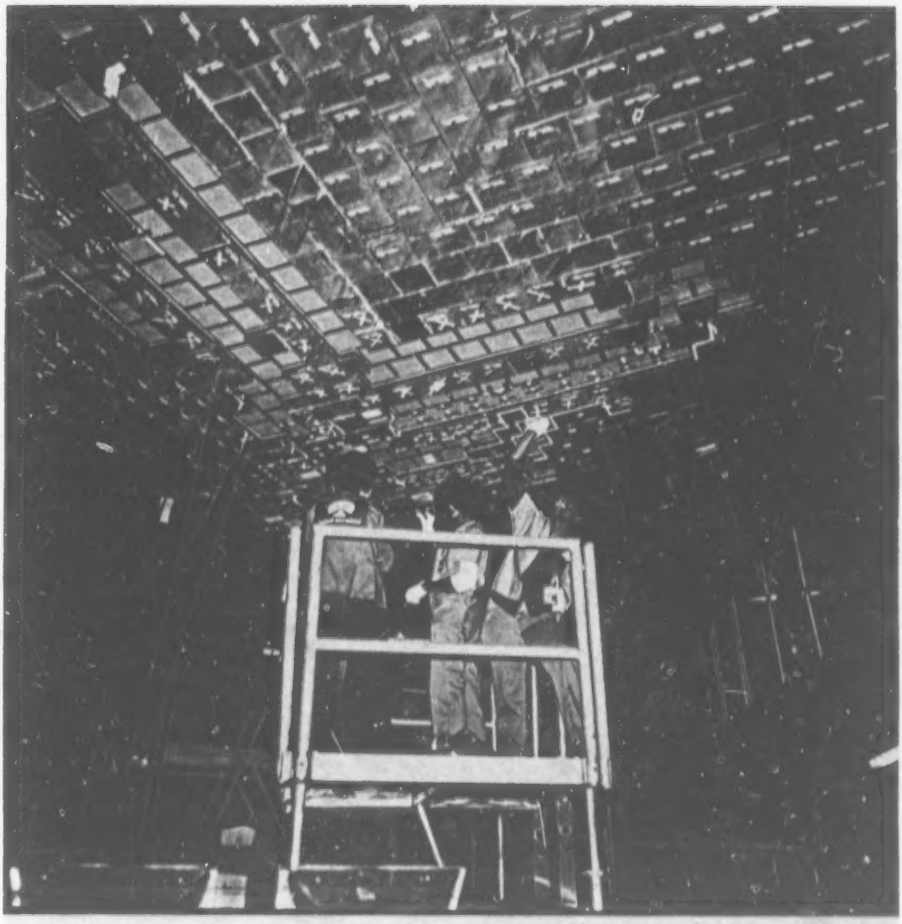
- ONE MISSION CONFIGURATION
  - SPACELAB FIRST FLIGHT
  - SIX-MAN CREW - TEN DAYS
- NO PLANNED EVA
- THRUST STRUCTURE CONFIGURED TO SUPPORT 104% THRUST (107% ABORT)
- AVIONICS RECHANNELIZED FOR VERSION 20 SOFTWARE
- ENTRY ANGLE OF ATTACK LIMITED TO 40 DEGREES
- ENTRY MANEUVER LOAD FACTOR RESTRICTED TO 2G'S
- LANDING SINK SPEED RESTRICTED TO 6 FPS



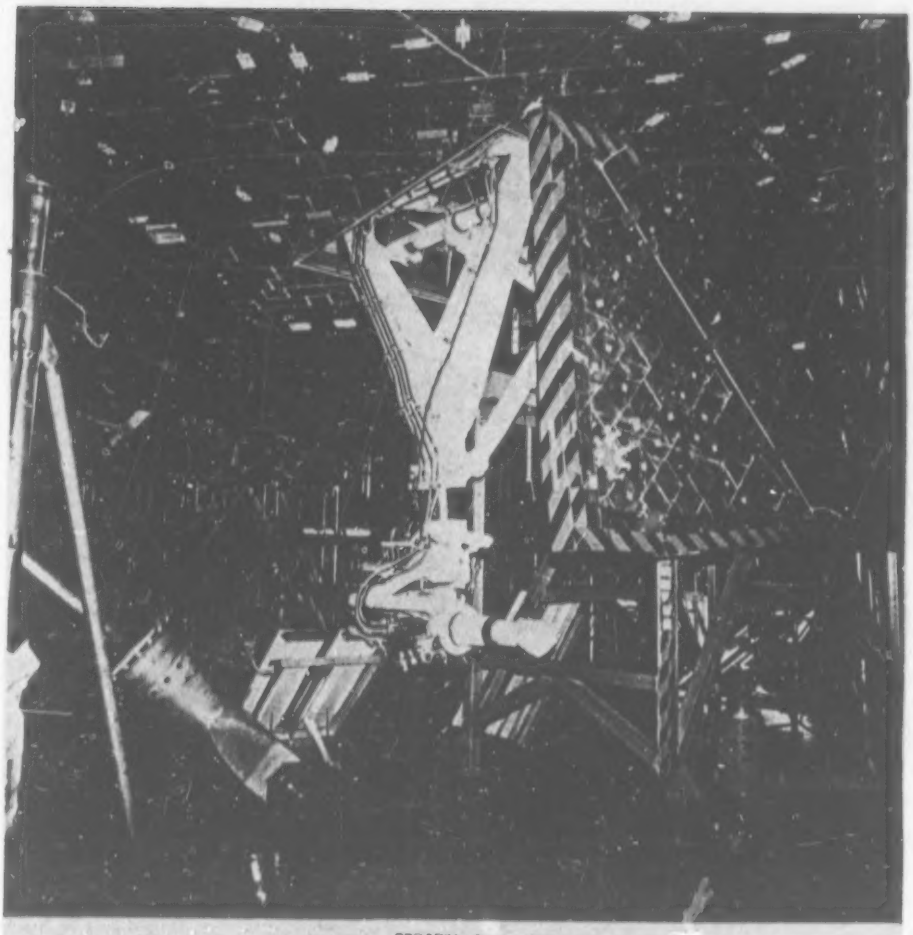
ORBITER 102 - AFT HEATSHIELD (FEBRUARY 1, 1983)



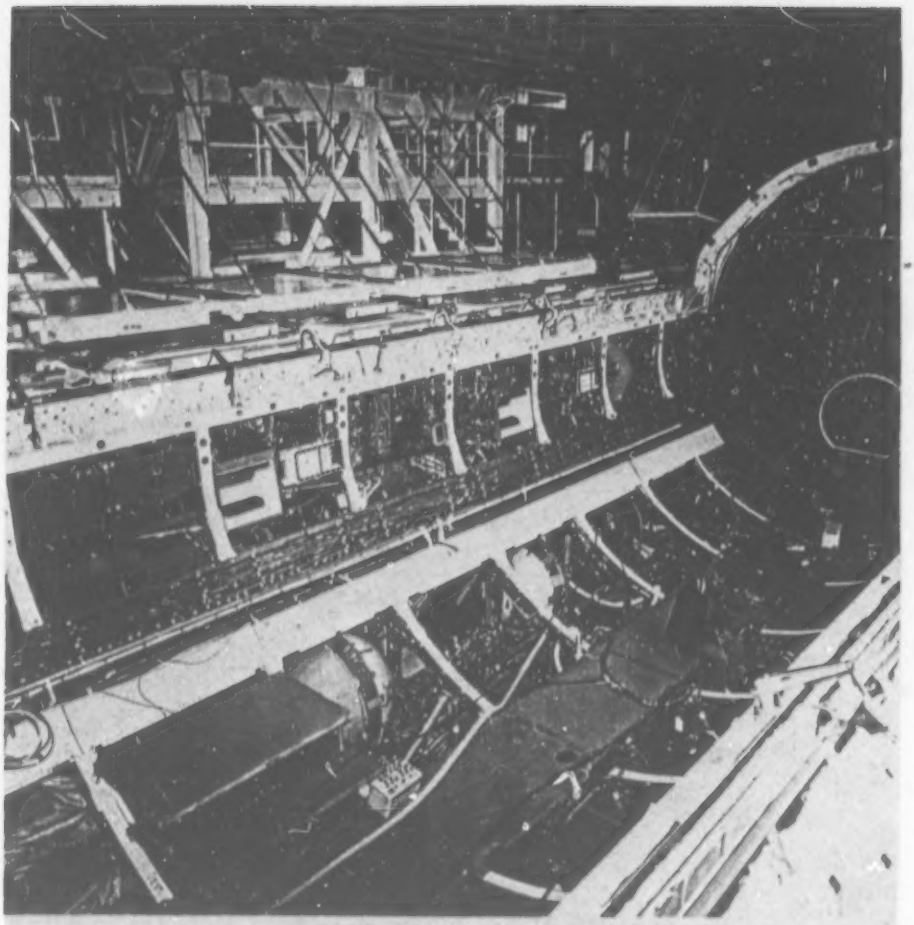
ORBITER 102 - LEADING EDGE SPAR (FEBRUARY 1, 1983)



ORBITER 102 - TILE DENSIFICATION (FEBRUARY 1, 1983)



ORBITER 102 - TILE DENSIFICATION (FEBRUARY 1, 1983)



ORBITER 102 - PAYLOAD BAY (FEBRUARY 1, 1983

OV-102 SLO MOD

Presentor: MA/A. D. ALDRICH
Date: FEB 25, 1983

- CORROSION
  - CORROSION FOUND ON WING LEADING EDGE SPARS GREATER THAN EXPECTED
  - REPAIR AND NEUTRALIZATION IN PROCESS
  - SCHEDULED COMPLETION IS JUNE 1, 1983
- WING LEADING EDGE PANELS (RCC)
  - 22 EACH WING
    - REMOVED FOR CORROSION CORRECTION ACCESS
    - PROCESSING THROUGH VOUGHT FOR SERVICE LIFE ENHANCEMENT
    - ALL PANELS BACK AT KSC BY JUNE 1, 1983
- TPS TILE
  - 2,450 LOWER SURFACE TILES WILL BE REMOVED, DENSIFIED, AND REINSTALLED
  - NORMAL TURNAROUND TILE REPAIR
  - TILE ACTIVATION TO BE COMPLETE BY AUGUST 1, 1983

OV-102 SLO MOD

Presentor
MA/A. D. ALDRICH
Date
FEB 25, 1983

FORWARD FUSELAGE

- CREW MODULE RECONFIGURED TO ACCOMMODATE 6 CREWMEN
  - SEATS
  - STOWAGE
  - OXYGEN
  - BUNK-TYPE SLEEP STATIONS
- PROVISIONS FOR SPACELAB
  - PANELS
  - WIRING
- REMOVAL OF DFI/INSTALLATION OF OI
- KU-BAND COMMUNICATIONS SYSTEM
- GALLEY INSTALLATION
- SCHEDULED COMPLETION MAY 22, 1983

OV-102 SLO MOD (CON'T)

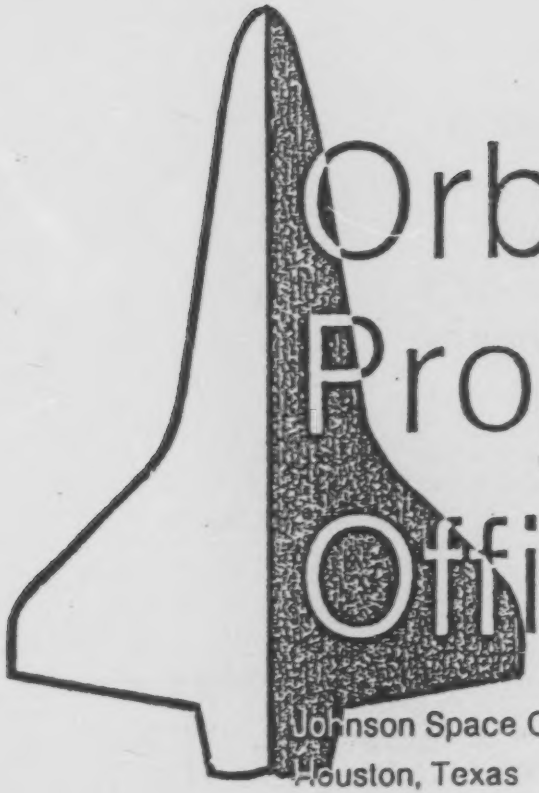
Presentor: MA/A. D. ALDRICH
Date: FEB 25, 1983

MID-FUSELAGE

- PROVISIONS FOR SPACELAB
  - WIRING
  - STRUCTURE
  - LIFE SUPPORT
- REMOVAL OF DFI/INSTALLATION OF OI
- TUNNEL ADAPTER INSTALLATION
- FIFTH PRSD CRYO TANK SET
- NEW FUEL CELLS INSTALLED
- SCHEDULED COMPLETION MAY 22, 1983

AFT FUSELAGE

- WIRING FOR OI
- UPGRADED GIMBAL ACTUATOR
- ADDITIONAL WIRING FROM T.O. UMBILICAL
- MODIFIED OMS GAUGING SYSTEM PROBES
- SCHEDULED COMPLETION MAY 22, 1983

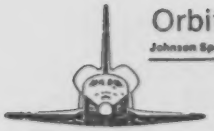


Orbiter Project Office

Johnson Space Center
Houston, Texas

OV-103

753



Orbiter Project Office

Johnson Space Center - Houston, Texas

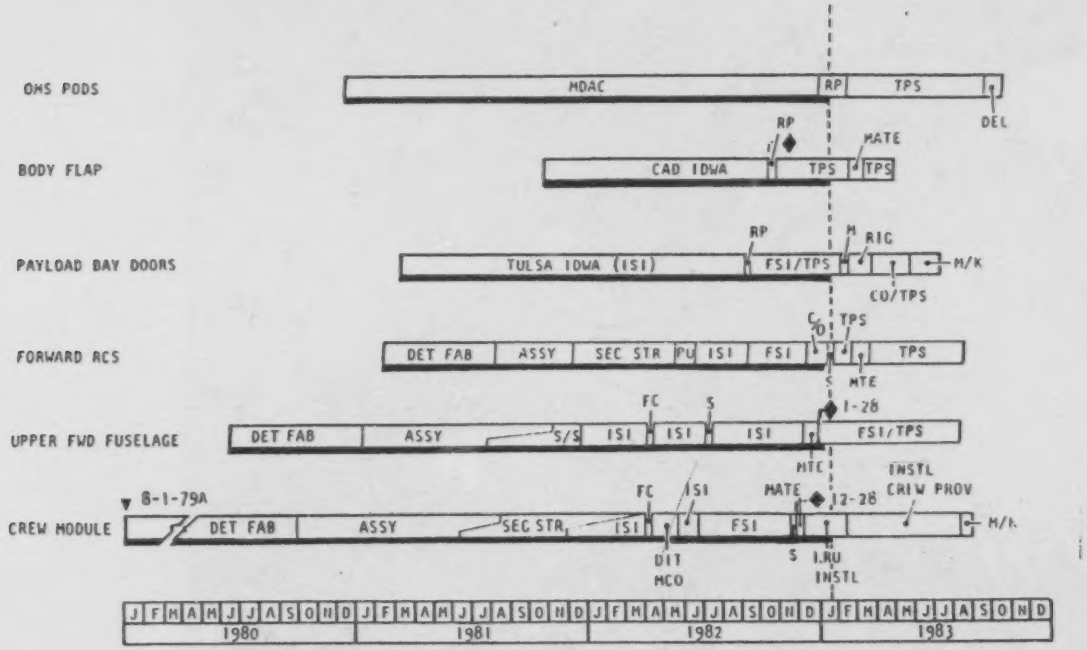
OV-103 STATUS	MA/A. D. ALDRICH
	FFR 25, 1983

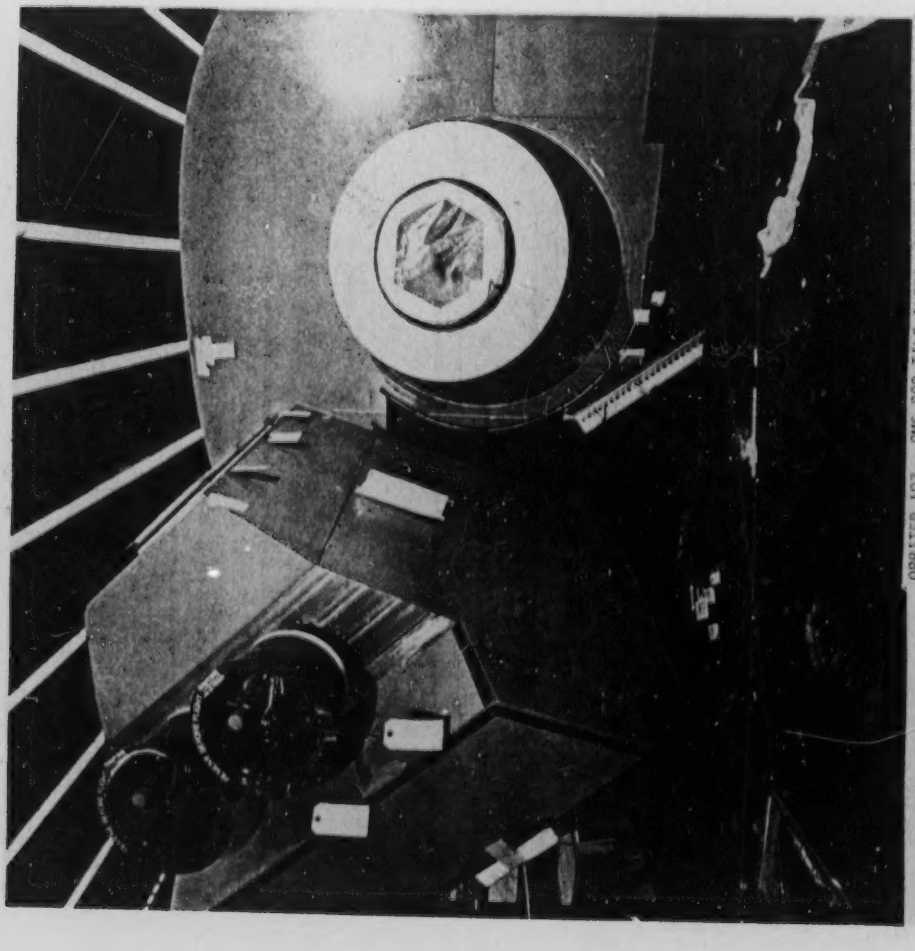
- VEHICLE IS ON SCHEDULE FOR SEPTEMBER 23, 1983 ROLLOUT
  - MATE OF CREW MODULE, FORWARD FUSELAGE, AFT FUSELAGE, AND WINGS IS COMPLETE
  - POWER-ON SCHEDULED FOR MARCH 4, 1983
- OMS PODS AND FORWARD RCS ARE AT PALMDALE
- MATE OF ELEVONS, VERTICAL STABILIZER, AND PAYLOAD BAY DOORS IS SCHEDULED DURING NEXT 30 DAYS
- TPS TILE INSTALLATIONS ARE AHEAD OF PLAN
- AFRSI BLANKET INSTALLATIONS ARE SLIGHTLY BEHIND PLAN

Orbiter Project Office
Johnson Space Center - Houston, Texas

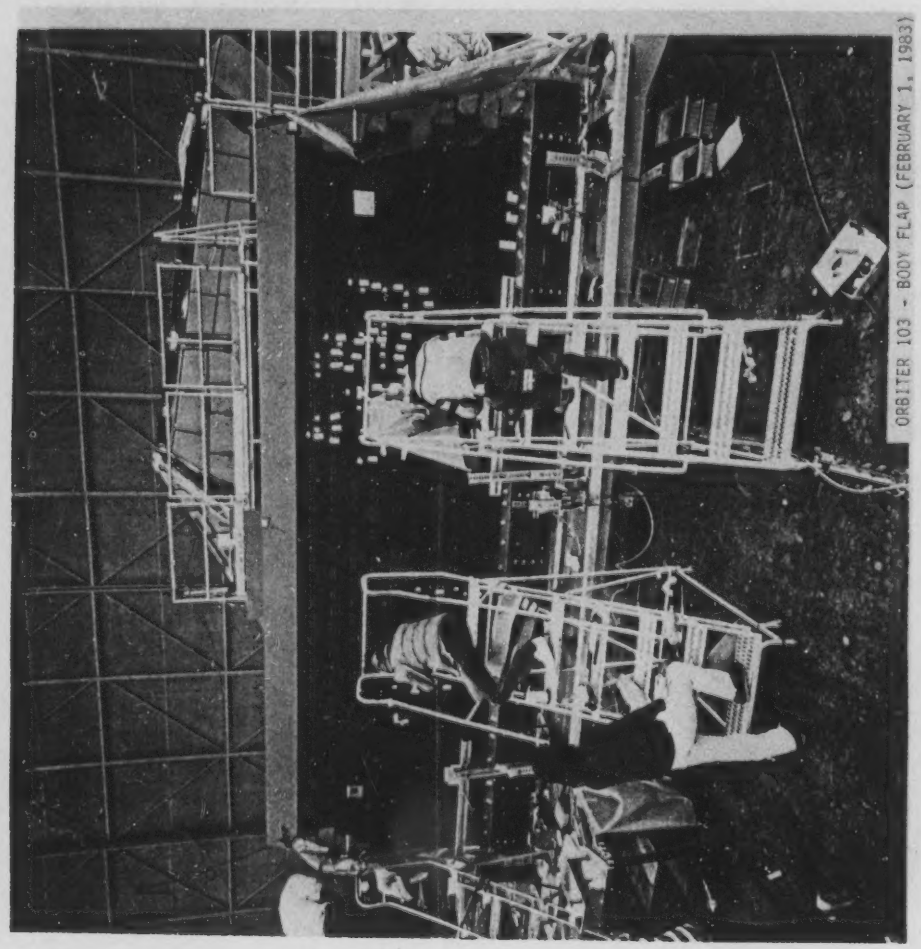
OV-103 MASTER SCHEDULE
MANUFACTURING WORK SCHEDULE

MA/A. D. ALDRICH
FEB 25, 1983



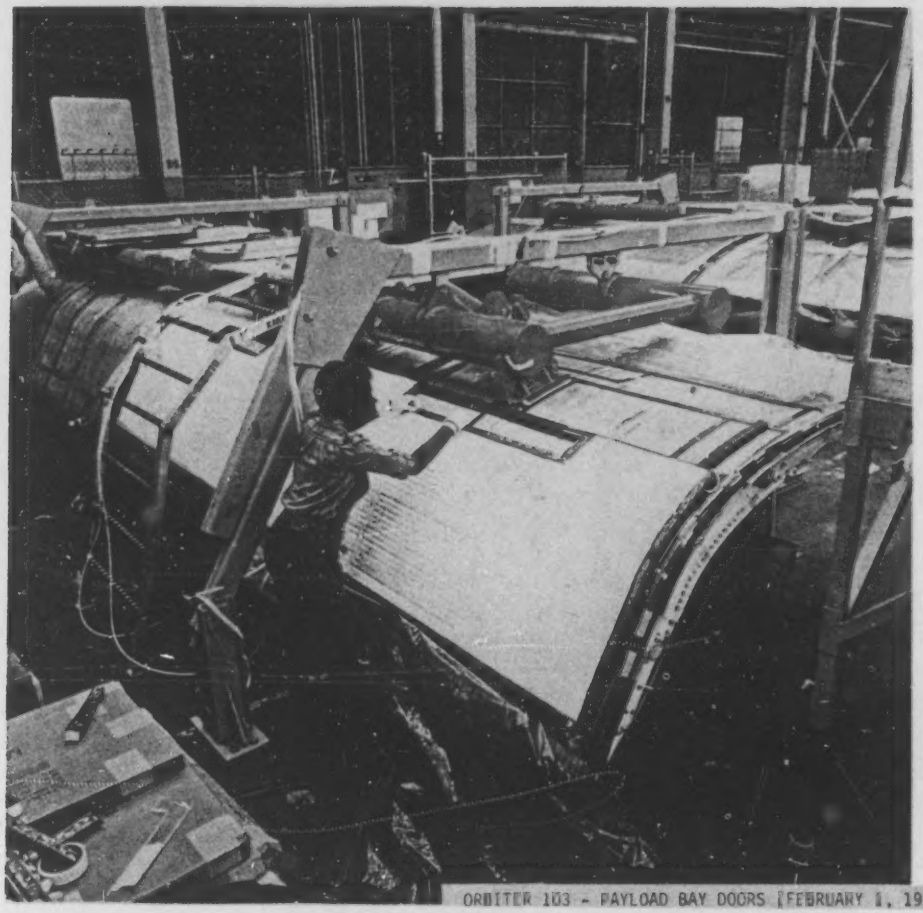


ORBITER 103 - OMS POD TILE INSTALLATION (FEBRUARY 1, 1983)

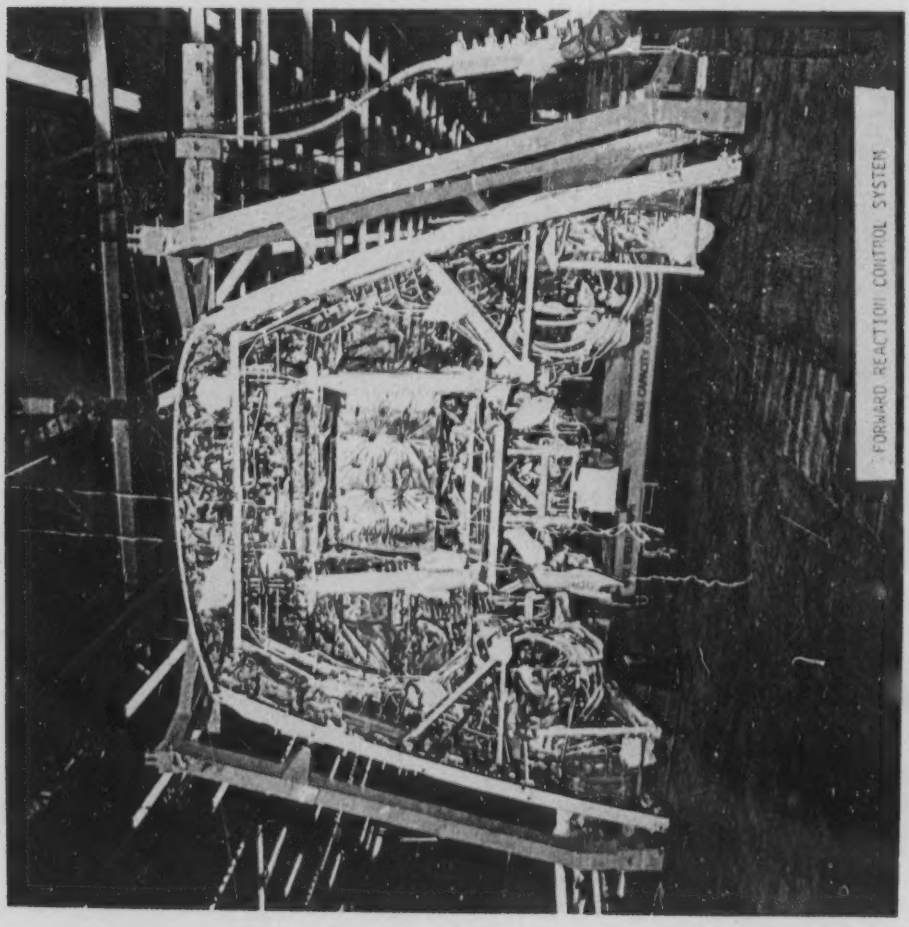


ORBITER 103 - BODY FLAP (FEBRUARY 1, 1983)

ORBITER 103 - WING ELEVON (FEBRUARY 1, 1983)



ORBITER 103 - PAYLOAD BAY DOORS (FEBRUARY 1, 1983)


FORWARD REACTION CONTROL SYSTEM

ORBITER 103 - (FEBRUARY 1, 1983)

Orbiter Project Office

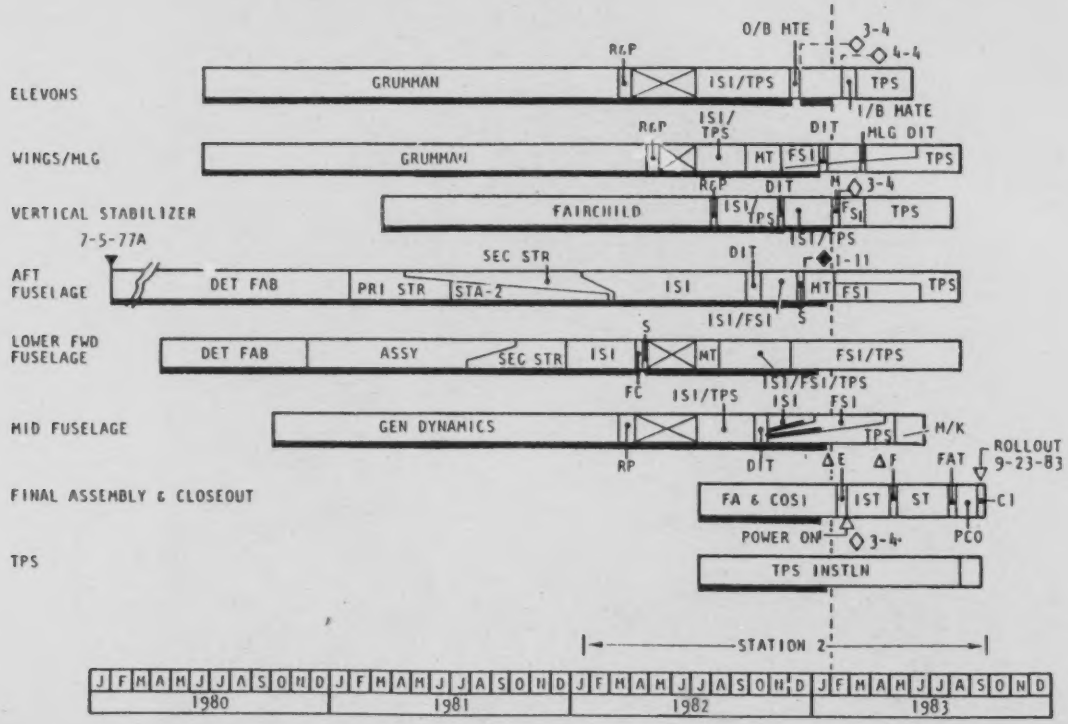
Johnson Space Center - Houston, Texas

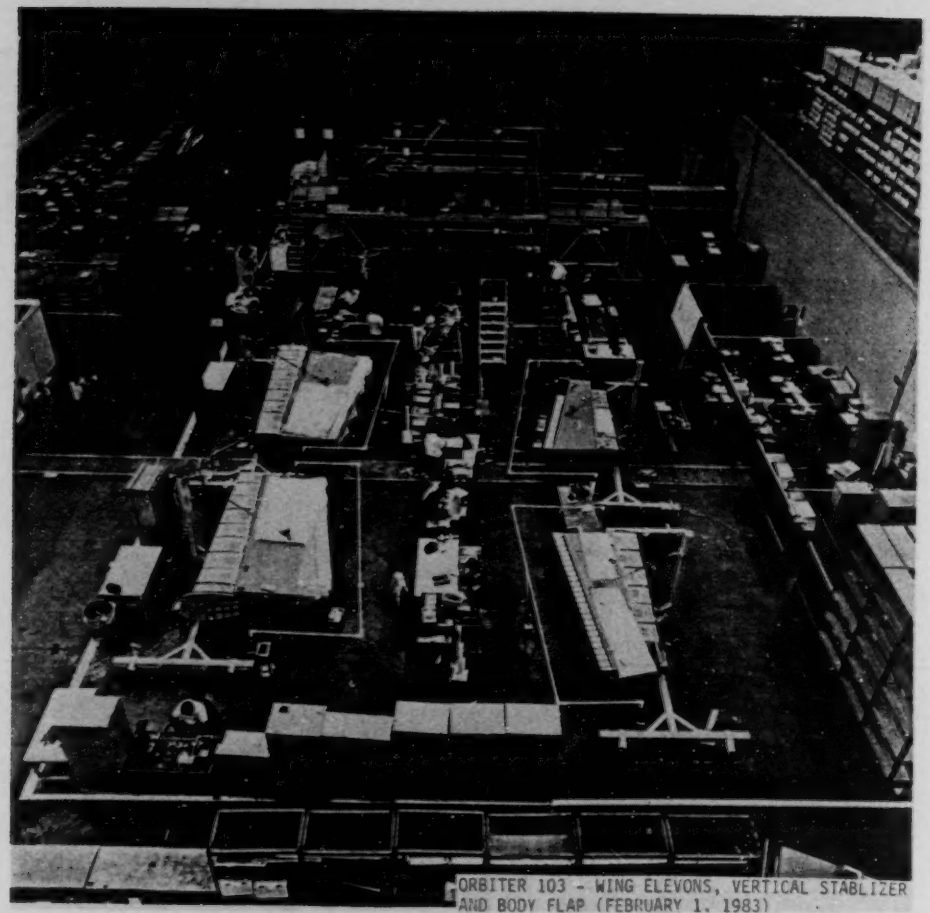
OV-103 MASTER SCHEDULE

MANUFACTURING WORK SCHEDULE

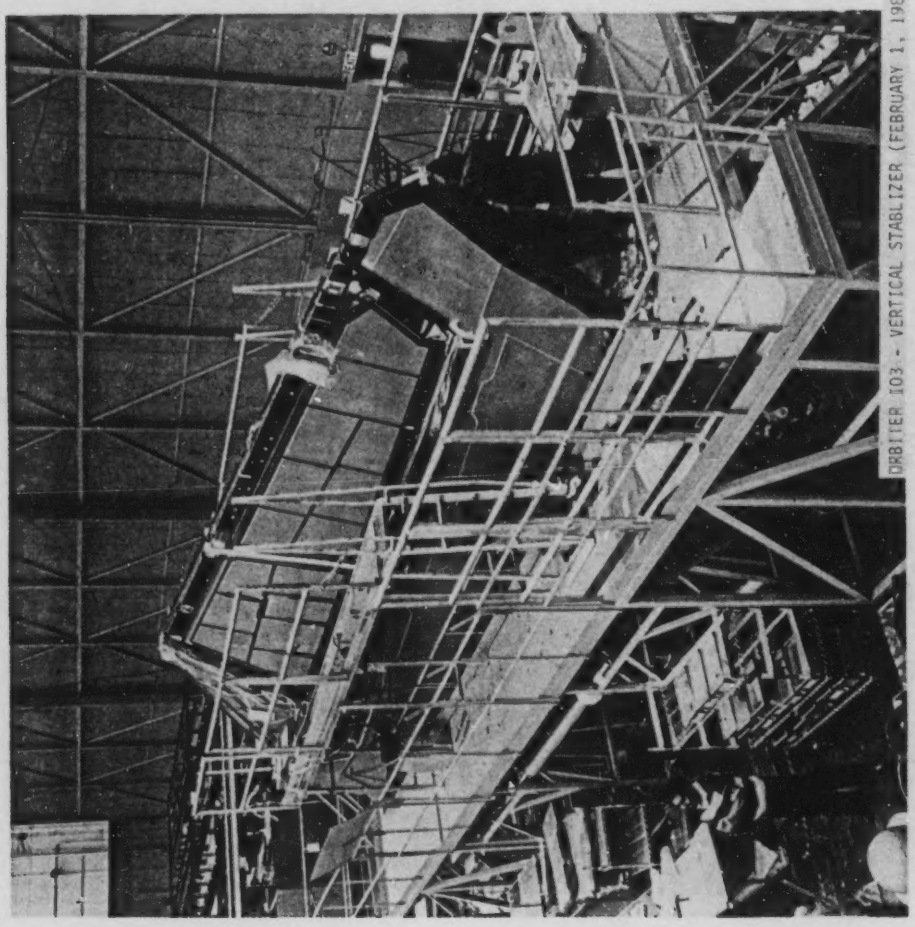
MA/A. D. ALDRICH

FEB 25, 1983

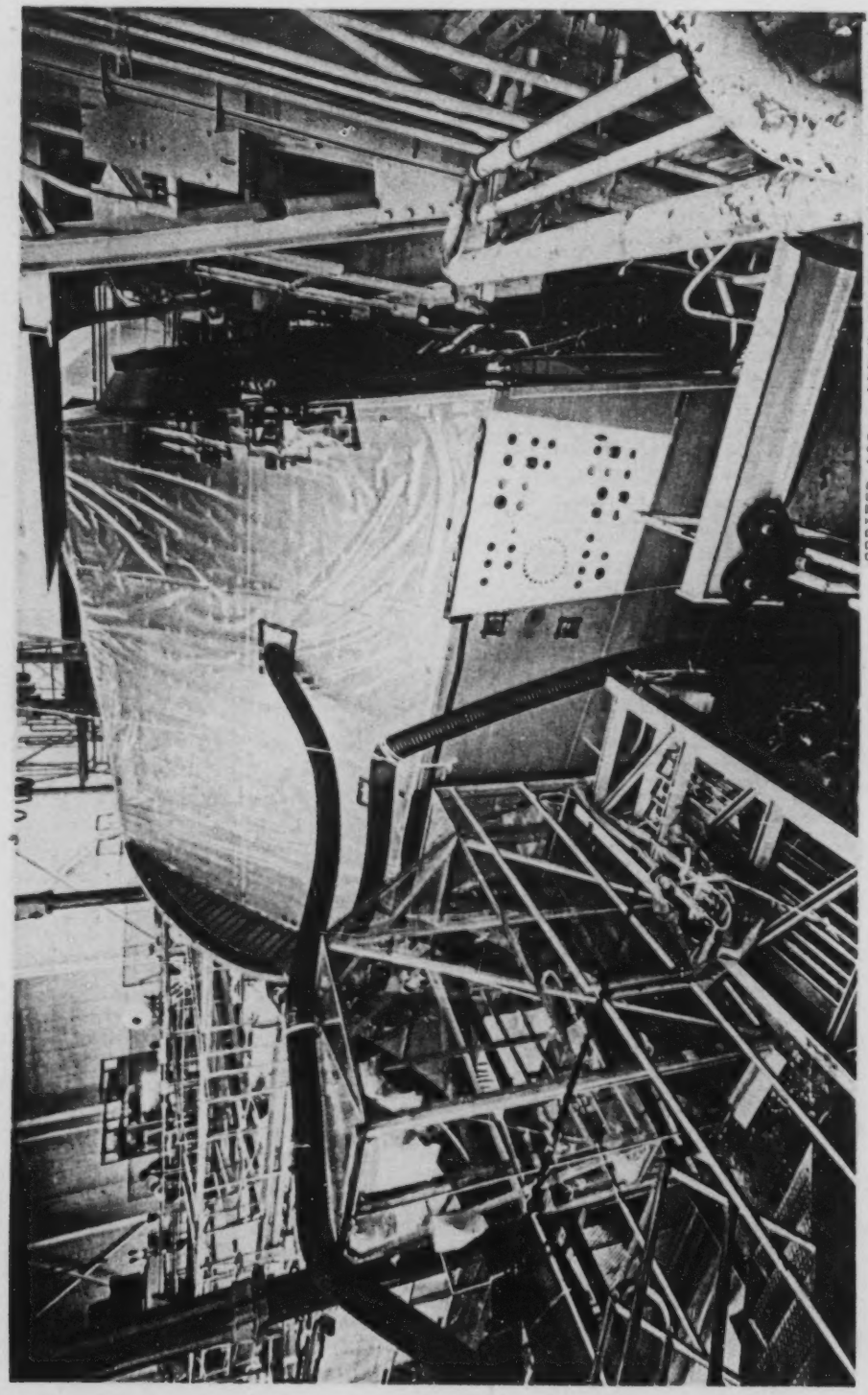




ORBITER 103 - WING ELEVONS, VERTICAL STABLIZER AND BODY FLAP (FEBRUARY 1, 1983)



ORBITER 103 - VERTICAL STABILIZER (FEBRUARY 1, 1983)



ORBITER 103 - AFT FUSELAGE (FEBRUARY 1, 1983)

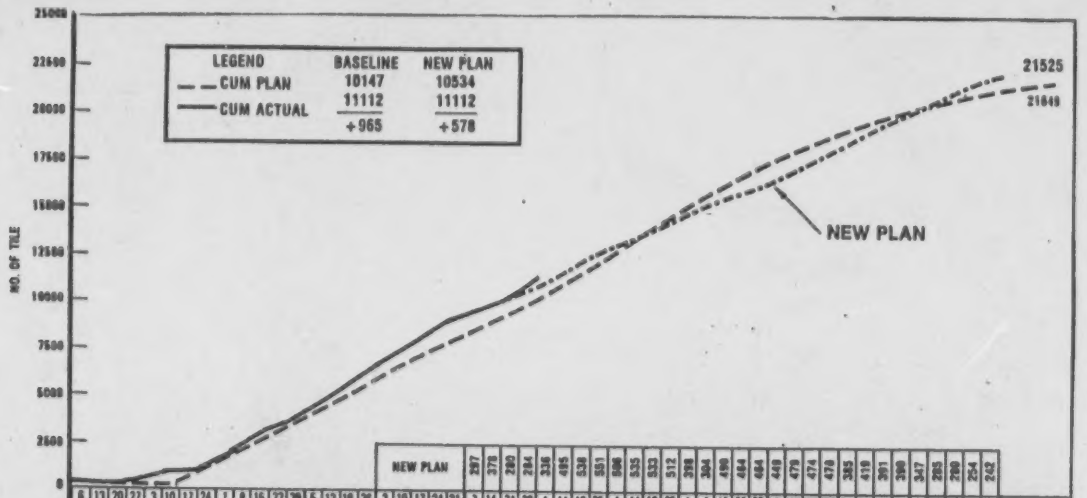
Orbiter Project Office

Johnson Space Center -- Houston, Texas

OV-103 TPS ON-VEHICLE TILE BOND SUMMARY

Presentor: MA/A, D. ALDRICH

Date: FEB 25, 1983



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NEW PLAN																							297	378	280	284	336	495	538	551	598	535	533	512	398	304	490	484	484	449	470	474	478	385	419	391	388	347	285	280	264	242							
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CUM ACT		140		140		140		140		75		215		332		764		432		1135		1786	2073	2584	3095	3730	3342	424	3919	4153	4464	4859	5436	6105	6593	7125	7683	8307	8754	9295	9582	10294	10717	11112																																						
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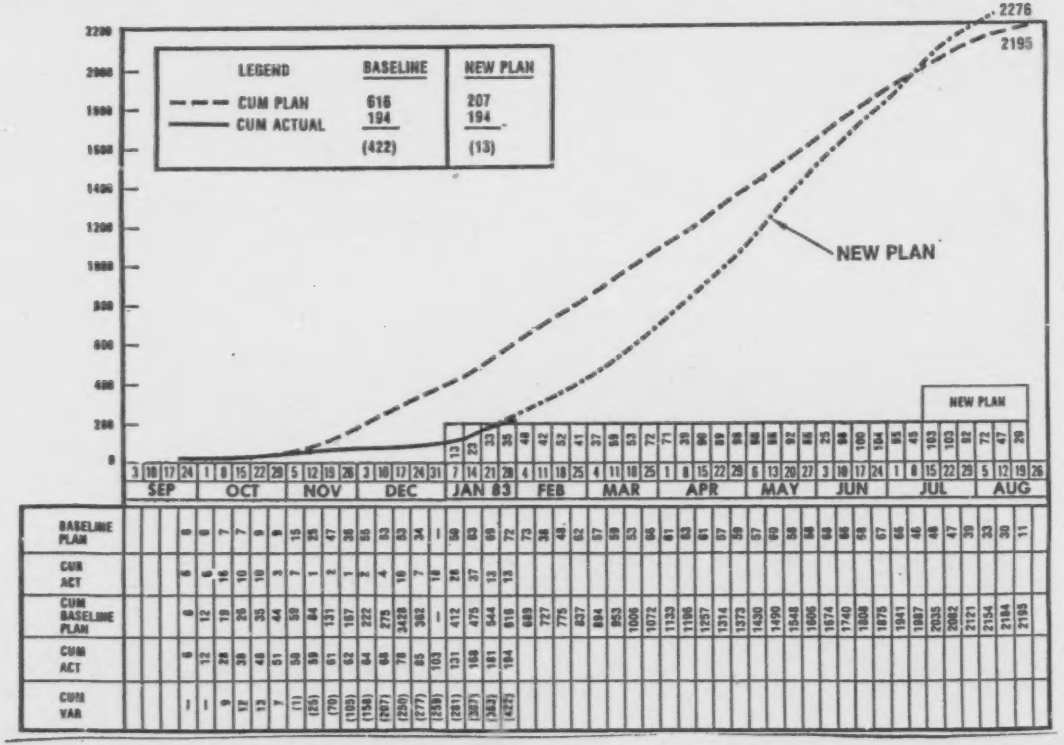
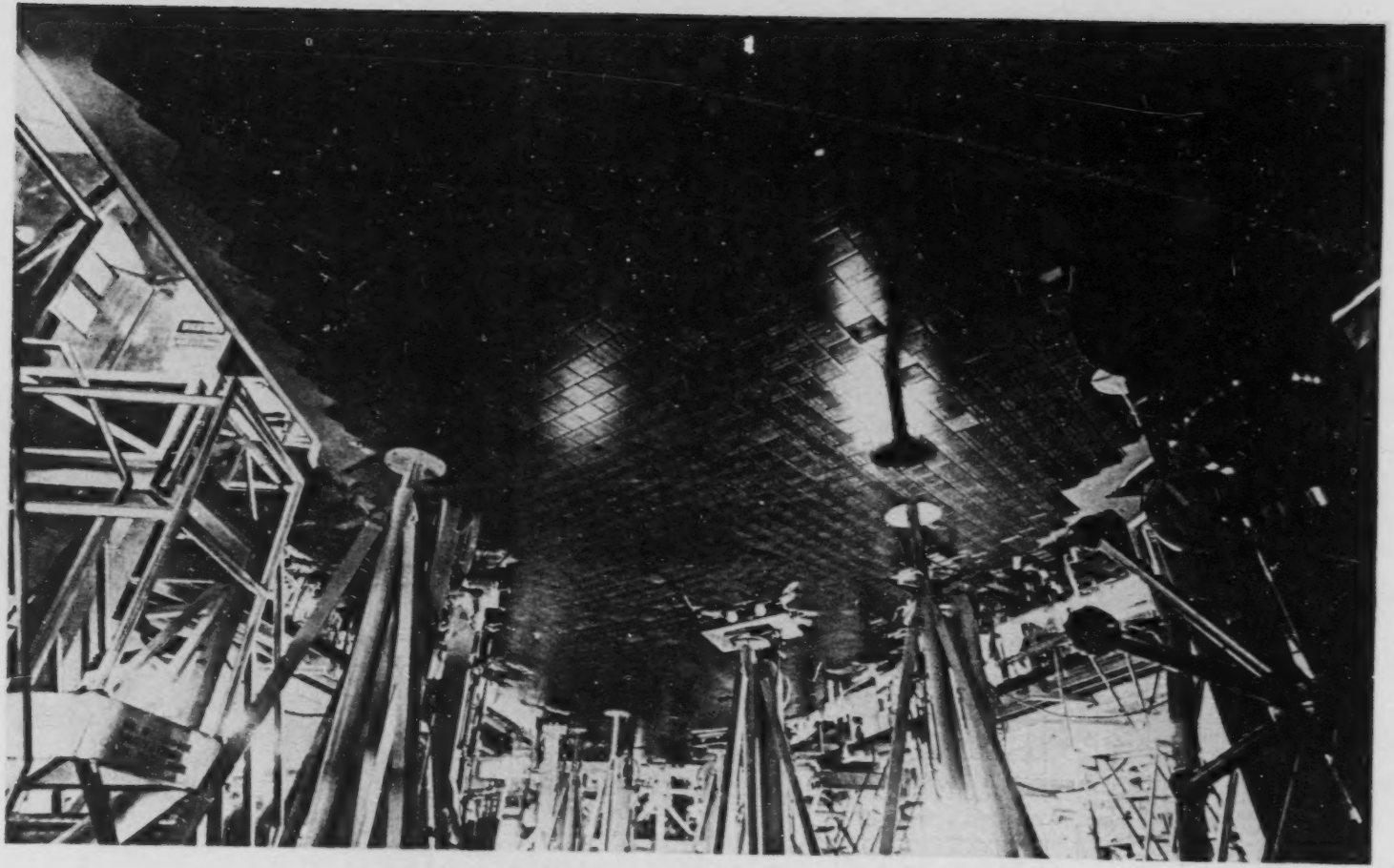
Orbiter Project Office
Johnson Space Center - Houston, Texas

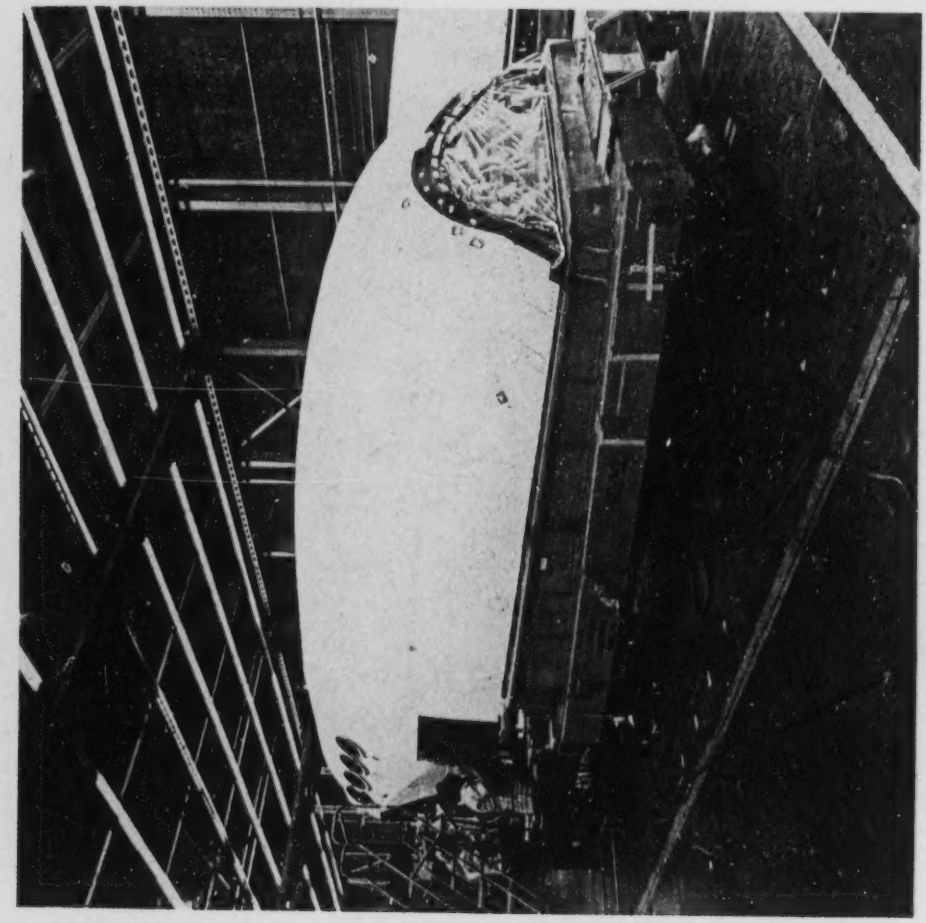
OV-103 THERMAL PROTECTION SYSTEM
TOTAL ORBITER AFRSI NET BOND SUMMARY

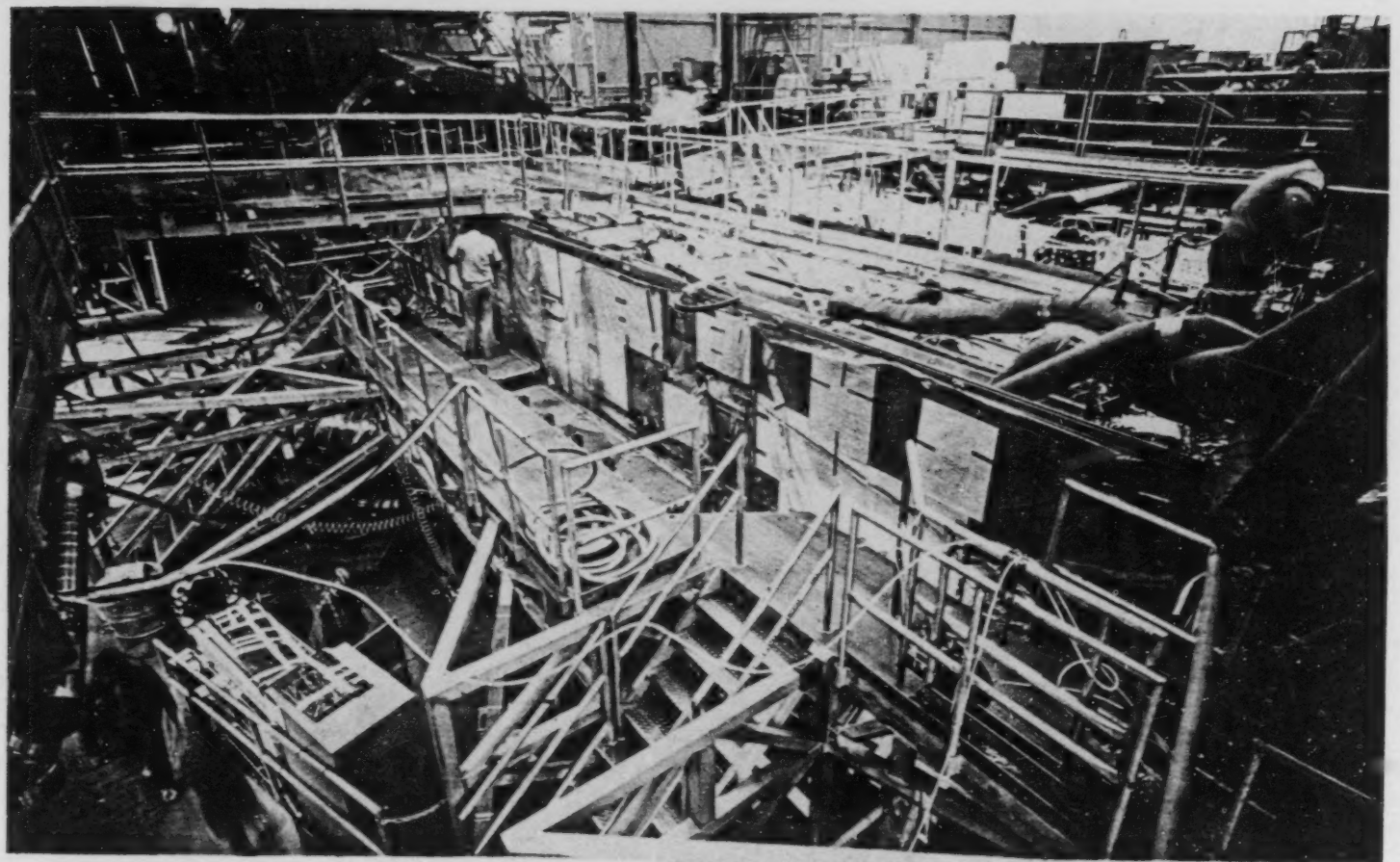
MA/A. D. ALDRICH
FEB 25, 1983





ORBITER 103 - TPS (FEBRUARY 1, 1983)





ORBITER 103 - MID BODY AFRSI INSTALLATION (FEBRUARY 1, 1983)

Orbiter Project Office

Johnson Space Center
Houston, Texas

OV-104

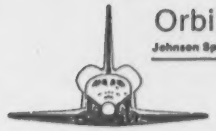
771

OV-104 STATUS

MA/A, D. ALDRICH

FEB 25, 1983

- DELIVERY IS SCHEDULED FOR DECEMBER 1984
- WINGS, MID-FUSELAGE, OMS PODS, PAYLOAD BAY DOOR, AND VERTICAL STABILIZER ARE ON SCHEDULE
- CREW MODULE AND AFT FUSELAGE ARE APPROXIMATELY 8 WEEKS BEHIND OPS 10, REV 2 SCHEDULE
  - DELAYS IN PARTS AVAILABILITY DUE TO HIGHER SHOP PRIORITIES TO GSE, MISSION SUPPORT, AND OV-099/OV-103
  - RECOVERY PLAN IN WORK.
  - EXPECT ON-SCHEDULE STATUS BY PLANNED POWER-ON DATE OF MAY 1984
- TPS TILE FABRICATION HAS BEGUN AT LOCKHEED



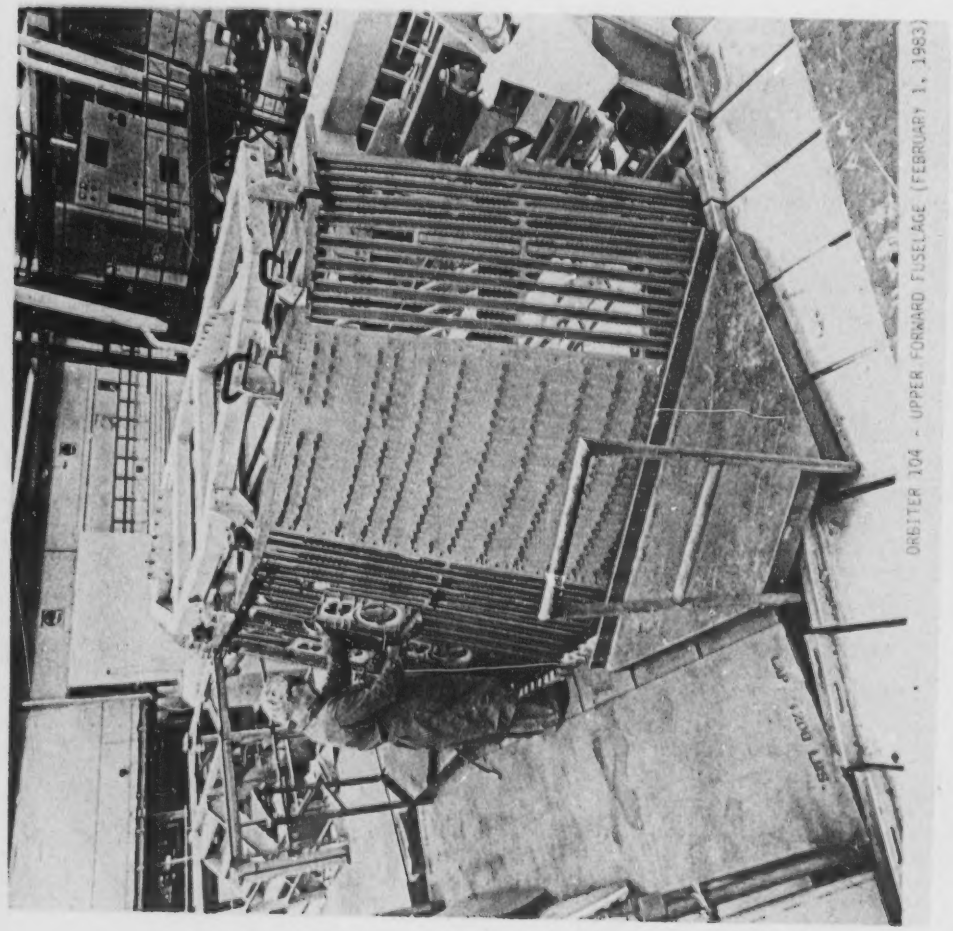
Orbiter Project Office

Johnson Space Center - Houston, Texas

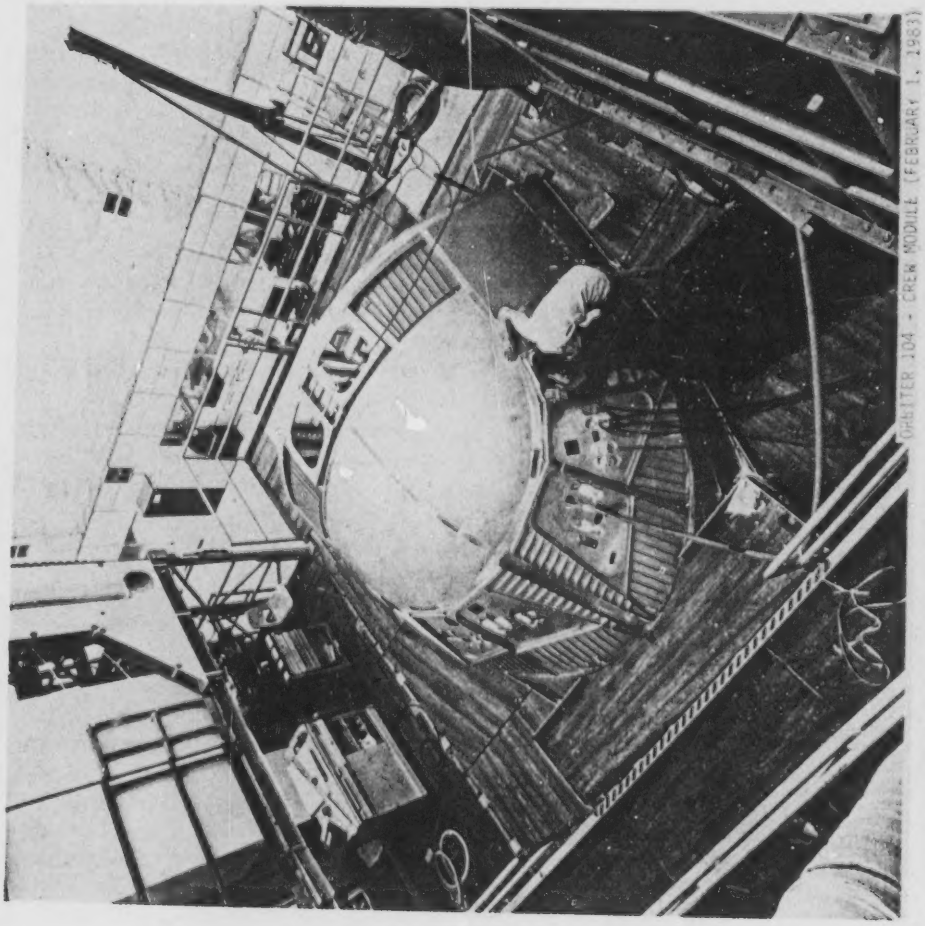
OV-104 STATUS	MA/A, D. ALDRICH
	FEB 25, 1983

- DELIVERY IS SCHEDULED FOR DECEMBER 1984
- WINGS, MID-FUSELAGE, OMS PODS, PAYLOAD BAY DOOR, AND VERTICAL STABILIZER ARE ON SCHEDULE
- CREW MODULE AND AFT FUSELAGE ARE APPROXIMATELY 8 WEEKS BEHIND OPS 10, REV 2 SCHEDULE
  - DELAYS IN PARTS AVAILABILITY DUE TO HIGHER SHOP PRIORITIES TO GSE, MISSION SUPPORT, AND OV-099/OV-103
  - RECOVERY PLAN IN WORK
  - EXPECT ON-SCHEDULE STATUS BY PLANNED POWER-ON DATE OF MAY 1984
- TPS TILE FABRICATION HAS BEGUN AT LOCKHEED

ORBITER 104 - FORWARD RCS (FEBRUARY 1, 1983)



ORBITER 104 - UPPER FORWARD FUSELAGE (FEBRUARY 1, 1983)

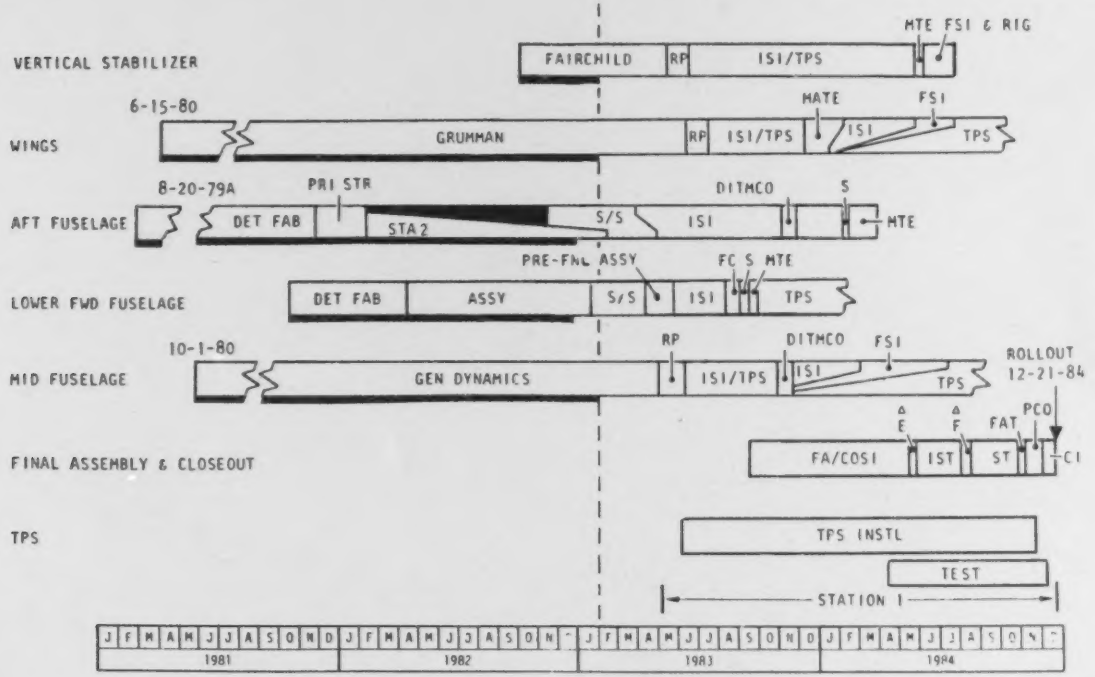


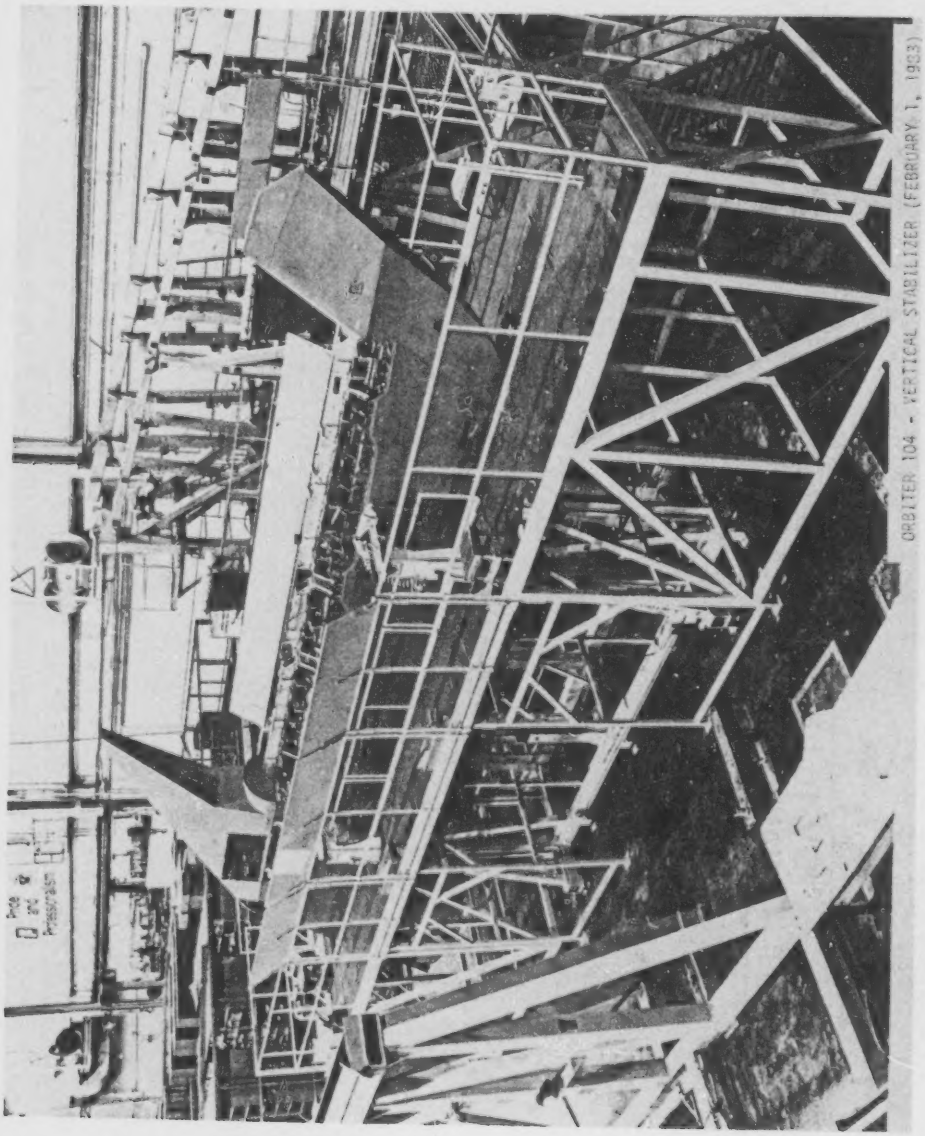
ORBITER 104 - CREW MODULE (FEBRUARY 1, 1983)

Orbiter Project Office
Johnson Space Center - Houston, Texas

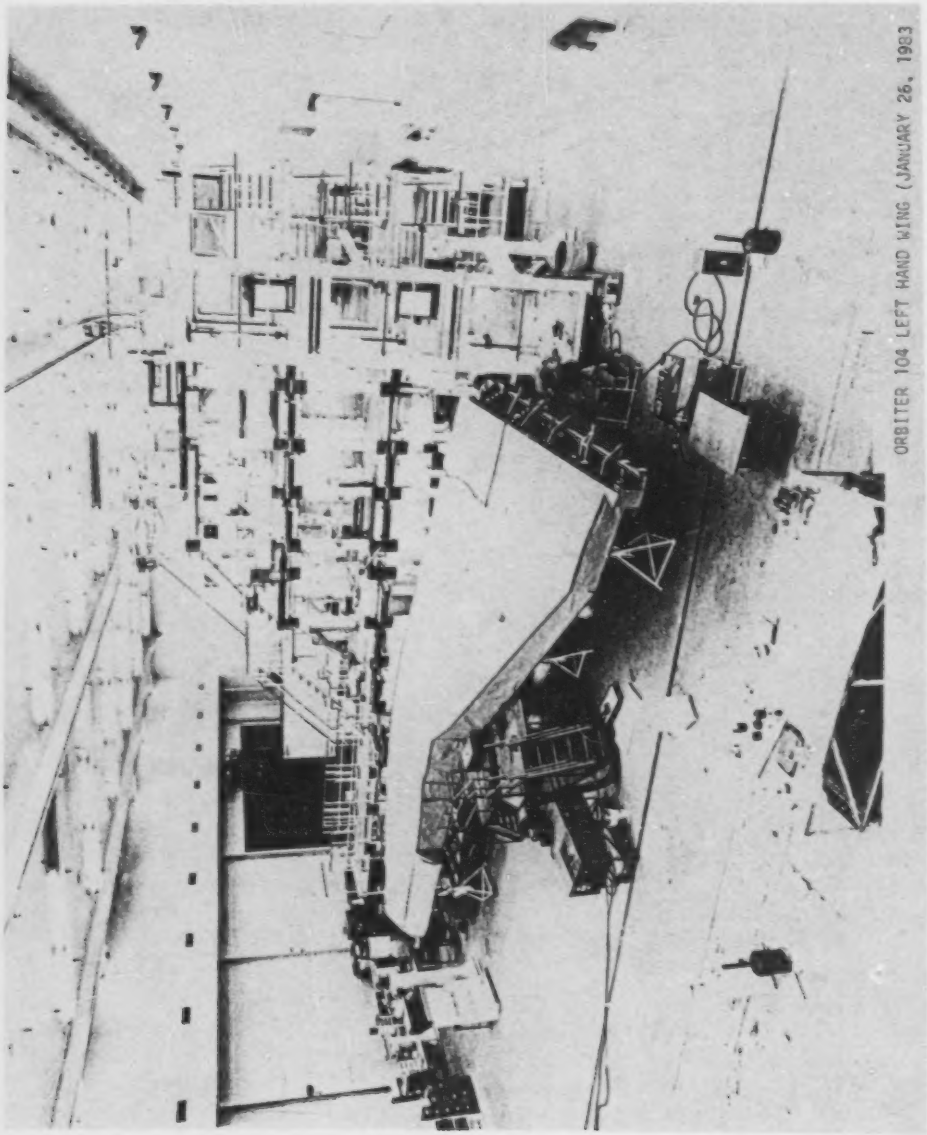
OV-104 MASTER SCHEDULE
MANUFACTURING WORK SCHEDULE

MA/A. D. ALDRICH
FEB 25, 1983

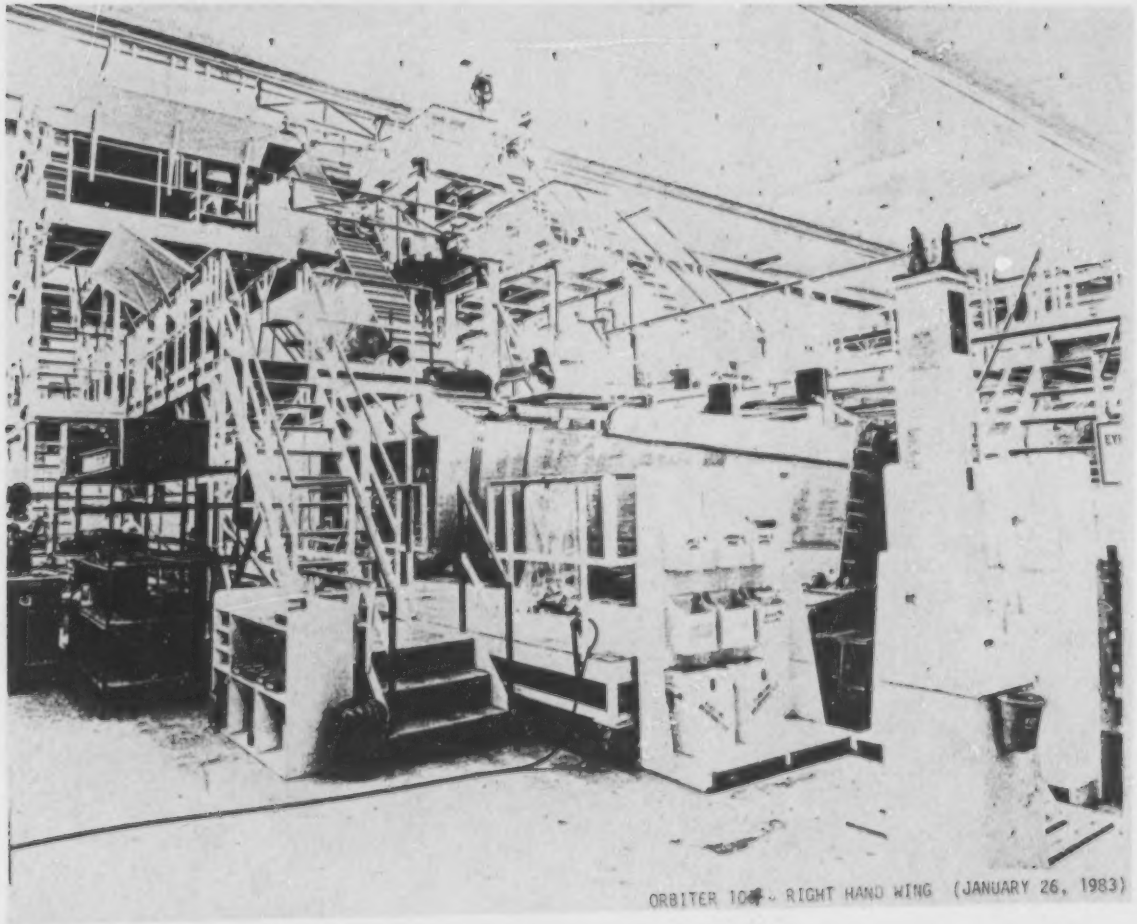




ORBITER 104 - VERTICAL STABILIZER (FEBRUARY 1, 1983)



ORBITER 104 LEFT HAND WING (JANUARY 26, 1983



ORBITER 10[illegible] - RIGHT HAND WING (JANUARY 26, 1983)

[Exhibit D-1.]

Mr. COVINGTON. The first thing I'd like to say is that this is, of course, not an approved program. What it is is an investigative program to really look at the missions, the mission needs, the mission opportunities, the configurational alternatives, system alternatives, and to try to define the planning in such a way that we can make an informed decision here in a few years of whether or not it should be a developed program; and that's what we're really doing right now.

Now, I did, though, go back to—I went back a few years to some work that we had done before to give you a feeling of just exactly what we mean when we say "space station," and how it really fits into the overall picture of what it is we're about here, before I get into what our status is on this investigative program that I was telling you about.

Now, we start with the shuttle. This is what we've got; and the shuttle makes a big difference to us, of course. We talk about the low cost space operations and the fact that we can now put up bigger things than we could before on the expendable launch vehicles, and we can bring things back.

This is very important, but the thing that we can do now, I think that nobody else in the world can do is this routine on-orbit manned operations. We have the opportunity to do that now. We referred earlier to the fact that the Ariane, this French launch vehicle, is competing with us now for launch services; but that is an unmanned vehicle, and there are things you can do with the shuttle that you can't do with that. I think that's the thing there that we want to grab and explore for this country and take advantage of it.

Congressman LUJAN. Ariane is unmanned?

Mr. COVINGTON. Yes; it's like the Delta or the Atlas.

At the present, there are only two manned programs in orbit, primarily; that's the United States and the Soviet Union; but there's the threat of one from Japan and China and some other countries, too, right now, because they're working on them, we know.

Now that we have this difference with the shuttle, this is the thing that I think we really want to exploit. The shuttle can do considerable amount of work on orbit because it has a crew there, and we are developing this routine operational capability.

[Exhibit D-2.]

The shuttle was designed with operational limits, because you have to have some limits, and they're not deficiencies, but they are limits. One limit is this larger payload bed that has a 15-foot diameter and a 60-foot-long capacity for carrying something. And with a due east launch, nominally, the specification is to carry 65,000 pounds with the easiest launch due east from the cape. The crew size right now is limited to about seven, because that's what it was designed for. We're looking, for space station purposes, for versions where you can put 10 seats in there, where you could have 2 people flying it and maybe bring 8 people back and take 8 people up. But it's configured right now for a maximum of seven.

Mission duration is nominally up to 10 days, and I think that's what the spacelab's going to fly. It's operational regime now is in

low earth orbit; that's where it delivers things to. And when we say "low earth orbit," we usually mean in the 150- up to about 300-mile range, although, with some diddling with the trajectory, it can take things a little higher than that. But it's operating area is low around the Earth.

Now, there are a lot of commerical things that want to be higher, of course, up in this unique orbit that we call geosynchronous orbit. It's over the equator at 22,000 miles. I think you're familiar with the uniqueness of that, and that is, the period of the orbit is exactly 24 hours. Of course, with the Earth rotating once each 24 hours, something placed in that orbit appears to an observer on the ground to stay in the same place all the time, and that's why our communication satellites are there.

The uniqueness of this orbit, too, is that it's just a line around the Earth and it's beginning to get crowded; so we're interested in things that could alleviate this crowded condition, because we've got a lot of communication satellites from countries all over the world up there now.

We have increased the capability to put things—

Congressman LUJAN. Excuse me. How many, would you say, objects are in geosychronous orbit,

Mr. COVINGTON. I think there's 60 some odd. Joe, do you know exactly how many today?

Mr. LOFTUS. There's some 68 active communication satellites. There are another 200 and some odd which are demised, and counting all of the various other bits and pieces, there is some 2,000 pieces in that orbit.

Congressman LUJAN: Is there any thought of going up and cleaning the backyard?

Mr. GRIFFIN. If you could get up there you could do it.

Mr. COVINGTON. That's a pretty good question that's interesting for anywhere in space that you might be interested in discussing in length sometime, too. It's a subject in itself that has a lot of significance.

Mr. GRIFFIN. If we could get up there, it would be advantageous to clear it out, but we have no way to get there to do that right now.

Congressman LUJAN. Not yet.

Mr. CONVINGTON. Now, when I say overcrowded, I mean with these 68 active communication satellites there. And the reason they're overcrowded is because even though this is a line or a circle around the Earth that's very long in length, you've got to separate these things to a certain distance to be able to separate the communication links from one satellite to the other. We do that by putting big systems on the ground that have a high enough gain to put a small spot up and grab one of them, becuase the antennae in space are fairly small and they illuminate the entire northern hemisphere, usually. So that's the way we do it today; and so consequently, we've been separating them by about 4 degrees in orbit which is about 800 miles.

Now, there are little tricks you can use to go to higher frequencies where you can put these closer together; but to keep them spread takes up a lot of space, and that's one of the things that we're looking to the future to think about what are we going to do

about that kind of problem, because the commerical services and communications just keeps growing by leaps and bounds.

We could take 5,000 pounds up there now with the inertial upper stage, and with this Centaur G-Prime, we can carry about 13,500 pounds of payload to geosynchronous orbit, which is a considerable increase over what we could do.

Now, there are things that you have to consider on the shuttle that have to do with an achievable load factor and where you put the center of gravity. Even though the payload bay is big and it can carry 65,000 pounds, it doesn't work out usually that you end up with 65,000 pounds in there just as you filled up the payload bay. So achieving that condition there is what we call 100-percent load factor, a load factor of 1. So usually you don't fly with a full load factor of 1, and so that's something that you consider on the shuttle.

Another consideration is the time that it takes to turn around the spacecraft once it delivers a payload. Getting that as short as we can, there's still going to be a finite time associated with that.

Quick reaction time: there is a time that it takes to load fuel and the requirements just to get it all together and launch it. This could be important to somebody that wants to put something in space immediately. You need some asset there for some security reason that says now we need something. And that's a concern with the shuttle or any other kind of launch vehicle.

And then there are the launch considerations that are associated with the vagueness of the weather and the launch wind considerations that go along with where you want to put something when you get up there.

But there are design limits on the shuttle, and even though we've raised these limits considerably, there are some.

[Exhibit D–3.]

Now, we're looking at what requirements we think we're going to see out into the future, and what we think we would be required to do with space operations on out into the nineties and past the year 2000. And in thinking about these things, we think probably we can accomplish these goals most effectively by space basing our operations.

With the shuttle, we pushed to the limit in being able to ground base our operations. We carry everything back to the ground, and we take it back up with each shuttle launch. We carry the crew up; we carry the equipment up that we're going to work with—we take it up and down.

We think that if we can establish an integrated system that operates in space with several major elements of the pieces, that we can just about satisfy whatever needs we can postulate on out through the turn of the century and do it very well and better than anyone else in the world, we think. And generally, the big pieces of this system would be the shuttle, which we have; a space station, which space bases the capability that the shuttle has given us now; some sort of a resuable orbit transfer vehicle, and this is a thing like the Centaur, only designed to be maintained in space so that you could base it in space and reuse it like the shuttle, instead of having a ground-to-low-earth-orbit shuttle, we would establish an orbit-to-orbit shuttle that would stay at a space station and go out

to geosynchronous orbit, take payloads, come back, and be recovered and refueled and serviced and used again.

Chairman Volkmer. Manned?

Mr. COVINGTON. I think early on it would not have to be manned. I think sometime on out into the future, for reasons that you're talking about here, like debris out in geosynchronous orbit, or as the assets in geosynchronous orbit get bigger and more valuable, just as we want to put people in the shuttle in the low Earth orbit to do these operations, I think we're going to want to take people up to geosynchronous orbit to do the same kinds of things with our assets there.

So I think we are talking manned out into the future, but I'm really not talking manned when I talk about the space station program early on for this orbit transfer vehicle.

Now, the other two really big things that complete this system are the things you do up there, too, that we generically call payloads; but this is the science work, the applications work, the Earth sensors, the commercial processing things that free-fly that are payloads that you carry up; and then the fact that we have a crew there to do this operational work on a routine basis, where they're inside a spacecraft, inside a space station, or in a space suit outside or augmented in some way.

[Exhibit D–4.]

And pictorially, it looks something like this. The shuttle, the fact that we've got people there to operate the things we're going to do up there, and that's what makes it all happen right there; that's the bottom line: a better system that's more cost-effective to shuttle from orbit to orbit and back and recovering.

And then we need something in the middle that coordinates that, orchestrates it, manages it, controls it, and puts it all together; and that's what we think some sort of an operations base in space would be.

Now, that picture there means nothing. It's just a way of showing how, with things sized to fit inside the shuttle payload bay, you can put them together with pressure bottles in a tinker toy fashion to build up a capability to house people up in space permanently to where they are able to live and work productively and to maximize their productivity.

So the first step in that, of course, is the shuttle, and that's what makes it all possible. The next step, we think here is the space station that goes in the middle to space base this capability to do all of this. And that's what we generally mean by a permanent presence in space, when you're speaking from a manned standpoint: the capability to space base this capability.

[Exhibit D–5.]

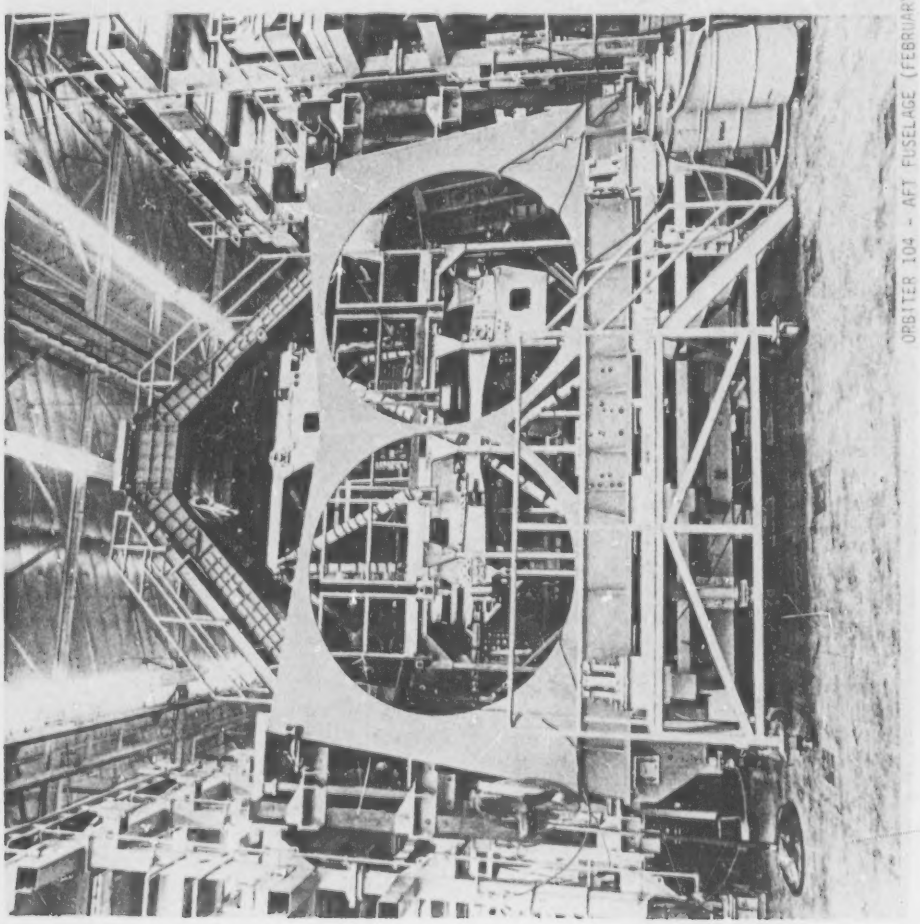
Now, in concept, you might say, "What is a space station?" Well, of course, it has to be shuttle launched because that's our launch vehicle. It's shuttle launched, it's serviced by the shuttle, it's put together by the shuttle, it's maintained by the shuttle, and it is permanent. You can't design something to be permanent, realy, but as a part of our design criteria, we would say that it had an indefinite lifetime with maintainability, and we would design it to be maintained on orbit by people. It's in low Earth orbit, because we think that's where the initial one really needs to be. It's sort of

a way station on the way to other places, and a place to do the things that we want to do in space that you could do on the shuttle, if you could leave a shuttle up for a year; but we don't want to leave a shuttle up there. We want to turn it around and bring it back down and use it for a transportation system. And we want to put it there for the operational support of the things that we want to do in NASA, that the commercial folks want to do, and that the Defense Department needs.

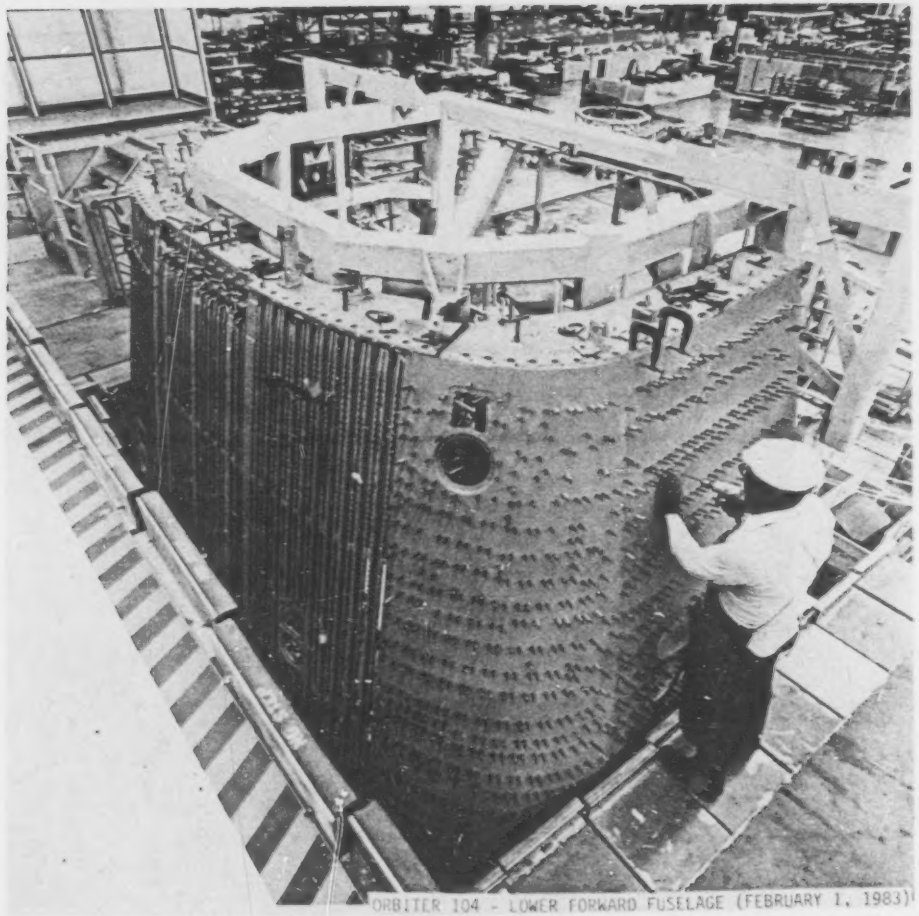
Functionally, it would do things like this: it would service satellites and payloads—and these are payloads that are attached to a space station that are coorbiting with it, that are not very far away in energy requirement, and that are even in higher energy orbits. With an orbit transfer vehicle, we can get out to higher energy orbit. Now, you might say, "Why do you want to service a satellite?" Right now, satellites are designed with high reliability, a lot of redundancy to where if you put them up and you want them to work for several years; and when they fail, they're gone. Now, with this shuttle and this manned capability, we know that if we preplan to maintain these things, we can design them in such a way that with a crew there they can take black boxes off, modules off, and put on new batteries, put on new propellant that controls their attitude, which is one way they fail most often, and do black box maintenance to these things. And in doing that, we should be able to lower the cost of the original design of these things. If you know you can get back and service it, you can lower the cost.

If you had to buy a car that was designed to operate for 5 years without any maintenance, it would cost a whole lot more than they do now, obviously. So that's the idea of doing that, for one thing. And, also, it opens up worlds that we haven't seen before.

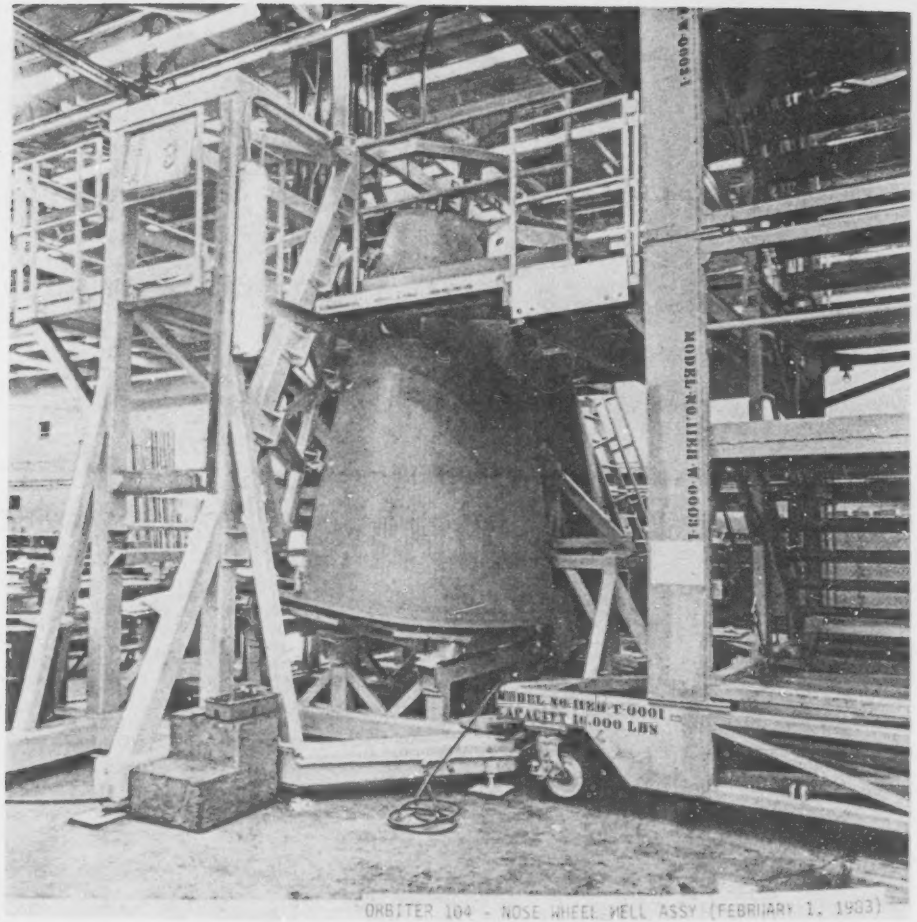
Now, one of these things is the kind of thing we're talking about here with Jim Rose, you mentioned. Jim is developing this process on the shuttle. This is the way the process works. We can make it work, and we can do commercial things like that. Now, his alternative from there is to build—McDonnell Douglas can build a little free-flying satellite that's a factory. And you can put this process on there, and you can leave it out there, because you really don't want people around banging into what it's doing. And he can develop—or you can make products. Now, another alternative is to have a space station there where he can have hands-on developers of, not the process, but the products themselves with the real time sensing and feedback loop of the human brain, the eyes, the hands. What his results are showing is that he can do it in an automated fashion on a platform and go to the shuttle and take products off of the—when he considers what he's got to do in terms of clinical evaluations and all that, he figures that in 15 years he can develop three new products in the pharamaceutical line that would not have existed before. If he had a space station where he could have a man on there doing it all the time, he says he could do 15—I'm sorry; I had it backwards. It was 15 in 10 years, rather than 10 in 15 years. So he could increase his productivity by a factor of 5 in producing things that wouldn't exist in the medicine line. So that's why he's an enthusiastic booster of a space station. Now, he says, "I can do it automated, unmanned with just the shuttle, and it would work better than it would on the ground. But if you give me



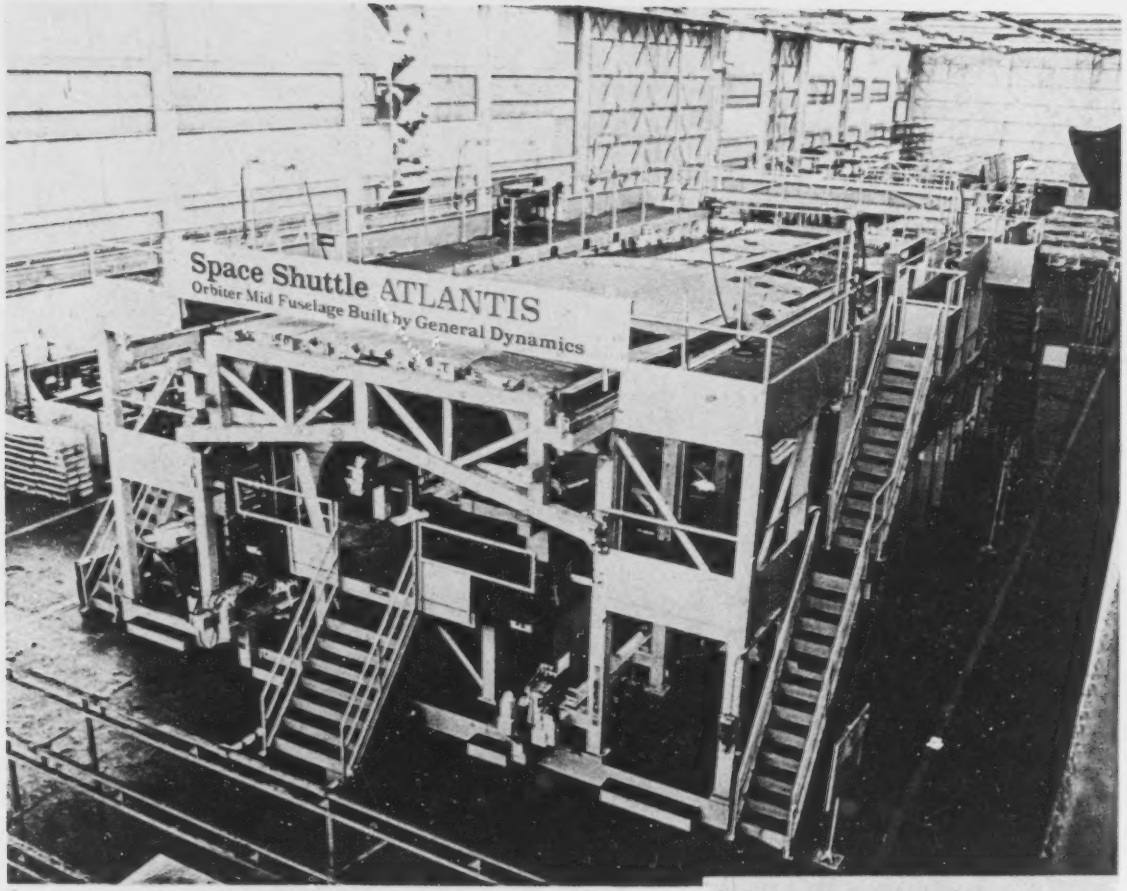
ORBITER 104 - AFT FUSELAGE (FEBRUARY 1, 1983)



ORBITER 104 - LOWER FORWARD FUSELAGE (FEBRUARY 1, 1983)



ORBITER 104 - NOSE WHEEL WELL ASSY (FEBRUARY 1, 1983)



ORBITER 104 - MID-BODY (FEBRUARY 1, 1983)

a space station, I'll increase my productivity by 5 and give people five times more things to work with."

Now, another thing that a space station would do: it would allow you to do long duration experiments, the process, for long periods of time. And this, in addition to the pharmaceutical manufacturing or processing, has to do with othe types of material processing—growing large crystals like the Soviet Union did on the Soyuz, where they mixed cadmium tellurite and mercury tellurite and grew a very large and very pure crystal that has application in Earth sensors and could have applications in all kinds of semiconductors in the computer world. Space and life sciences you could do on board a space station, obviously, because you have the long duration associated with it.

Earth observation: We look upon this, too, as becoming an orbital or space and research development facility that would be a little bit like having the old NACA at Langley up in space, where you can go do research and tecnology work in zero gravity with the facilities and the people there to do the work, supported on a routine basis.

And then the flight support of spacecraft like these orbit transfer vehicles that I was talking about, and to some extent, the shuttle while it's up there docked to it bringing supplies and rotating people.

And then space construction: The word "construction" sometimes scares people because you think of bricks and mortar. I nearly started not using the word and going to "assembly," but what we mean by "construction" generally is the clever design and folding of things into small packages and deploying them; or when you get to things big enough that you can't fit them in one shuttle payload bay—and when we're talking about alleviating this crowded condition out in geosynchronous orbit with communications satellites, one way to do it is to build bigger systems. If you put high gain sytems in space, you can put small stuff on the ground, build small systems on the ground, and really go to pocket communicators that size and put sophistications with the switching network in space.

Now, some of these things are bigger than you can put in one shuttle payload bay; but with a space station, you offload the operational constraints of the shuttle like that. You can carry up the pieces, and then a crew that stays with the right kind of equipment on a space station can put them together or assemble them, check them out, and then with some form of orbit transfer vehicle with low thrust can move them out to their operational orbit, geosynchronous orbit checked out and ready to go. And that's what we mean by "construction"; not a lot of hammering and nailing and stuff like that.

[Exhibit D-6.]

Conceptually, again, a space station, you can think of in two pieces. There's some core facility that has to be satisfied in order to maintain these working ability. And that has to do with the kinds of things that you always find on a manned spacecraft, starting with habitability and all the subsystems.

And then as you have these specific tasks to do, the station would also include missions specific equipment for servicing satellites and for assembling things and for checking them out and all

the sorts of special things that you would want to do, even down to the Defense Department kinds of things. You could, onto the core capability, then add the modular elements to be able to do these specific tasks. You could design it and build it and operate it modularly if we're really smart about how we do it.

[Exhibit D–7.]

To sum up, I think I've said most of this. But with the shuttle now, we have got lower cost payloads; we can bring payloads back; we've got routine operations in space; and we can begin to service satellites from the shuttle very effectively. And with the upper stages and the shuttle payload bay that we can stand off and launch, we can achieve better payloads to higher orbits with these upper stages.

If you had the space station, you get the benefits of having the continuous crew and equipment, not up and down, but staying in space; and we lift this mission time constraint that we have on the shuttle. If you're doing something on the shuttle in an assembly line or a service line and something happens to your time line and you just don't quite get through and you've got to come back down, well, you've lost it; so you have to be very careful on how you schedule and what kind of margins you put in.

On a space station with the equipment and the people up there 24 hours a day, you can schedule better, you can do the stuff more routinely, and you don't have to worry about not finishing it. We can achieve higher load factors. If the shuttle, then, can be more specifically a transportation system and we can relieve some of these operational things that we're probably going to end up wanting to do, by leaving those in space, we can then load the shuttle better because it's going to the space station to carry supplies. And then when we really get into large scale operations out to geosynchronous orbit with these orbit transfer vehicles, they require a lot of propellant, liquid oxygen and liquid hydrogen; and we can then achieve a load factor on the shuttle of 1 with every launch. Just about every nook and cranny, in terms of payloads that you have left over, you just carry that and propellant, take it up and store it on the space station because you need to take it up there and use it anyway. So we can make the shuttle operate more efficiently with a space station.

We can check out spacecraft before they're deployed. You can do that on the shuttle, too; but you can do it better on a space station. Any you lift the size restraint on payloads and stage size limits, because you can carry pieces of it in the shuttle in 65,000 pound chunks and put them together to whatever you decide you want in the shuttle. And it gives us tremendous operational mission flexibility to met whatever needs come along that we can't even visualize now in the future.

Now, there are several ways to go about doing the kinds of jobs I'm talking about. One alternative is to say, "We won't space base. We'll just build a bigger shuttle. If we've got a bigger thing to put up and we want to stay up longer, we'll build a new shuttle with a bigger payload bay and all that," and that's effective. You can raise the limit. But if you space base, you eliminate the limit, and you can get along quite nicely on 15-by-60-foot pieces.

Then, with the addition of this space-based reusable upper stage we relieve the constraints in going on out to geosynchronous orbit, and we can get larger payloads out there, reduce those transportation costs in the same way that the shuttle, by being reusable, reduces in the low-Earth orbit. And we get the capability we need out into the future for doing planetary missions or larger commercial things in geosynchronous orbit. The Department of Defense, I would think, is going to be very interested in getting out farther for security reasons, and it just gives us the flexibility, again, to meet the mission requirements that we're not really able to predict right now, but it takes us in the direction that we want to go.

[Exhibit D–8.]

We have, in analyzing these programs here, too, decided that there are a few things that we know we're going to have to do, probably. One is that it is just as smart to do this to where you can provide this capability in increments for a lot of reasons, because you can't follow the mission needs if you don't know where they're going better by doing it in increments. And you can also spread the cost—not the cost of putting it up so much as the cost of development of the high-cost items. You can spread these out and add this incremental capability as you need it. It would be good if each increment that we put in space, if we could justify its value by itself without having to justify it on the value of what comes next. But anything ought to justify its own existence in the piece that it goes up with.

We think the program increments are going to have to be done with flexibility, too, and a part of it goes along with this incremental rule; but we need to put the flexibility in the program to be able to accommodate the vagueness of this year-to-year budgeting process that we go through. And if you're incremental, we can more easily adapt to that sort of a thing.

Program requirement changes are always a very large cost item to us, and incrementally, modularly, we can handle that better. Also, we need to be able to take advantage of improving technology. We want to be able to add new technology. We want to be able to add new technology as it is cost effective for us to do it.

We also think that we want to design the station with element and subsystem modularity, and I mean really do it really in self-contained modules where we can replicate the station with low cost. You can draw a good case that instead of making a space station bigger and bigger and bigger as the needs grow, that you just say, "Hey, let's cut it off, and let's just replicate another one over there that's more specifically oriented to the mission needs of that one." It allows mission-specific configurations. If you want something purely dedicated to science, you can put it together for science with an attitude hold, a dead band that's very tight looking at the ground or inertia.

If it's all for construction, you can then build it with the facilities on there for construction when we get out to that kind of mission need. And I am talking pretty far out now.

Higher energy orbits: I mean here polar, near polar, Sun-synchronous, where the Department of Defense might want to be, the Air Force. And it would also be better then to allow for independent Air Force use. Modular design would allow you to pick the

modules you need to put together a configuration for your own specific needs better.

[Exhibit D–9.]

Now, I'll get to the status of where we are right now. We're working with a space station task force that's directed out of headquarters. John Hodge is the manager of that task force, the director of it, and it was established by our Administrator in May 1982. And it's an activity that is bringing in all the centers.

The purpose of this is to provide a focus and direction. This is sort of what I was saying awhile ago. We don't have a program right now. The purpose of this activity is to put a focus on our planning activity and define an initiative that tells us what the mission requirements are, what are the options, what are the trade offs, what is the advanced development that is necessary to be able to reduce the program risk in terms of cost of schedule, and then lay out the management alternatives—what have we learned from the programs we've done now and how might we be able to do them better and cheaper. And then to develop management/acquisition plans. And this just says it in another way.

[Exhibit D–10.]

That's what we're doing now. Later, we're going to define concepts so that we understand everything well so that we can get an informed decision from the administration and from the Congress when it's time to do that.

Chairman VOLKMER. Can I ask a question in that regard right now? Most of this or almost all of this is being done in-house right now; is that correct?

Mr. COVINGTON. Yes, sir; most of it is because we don't have very much funding.

Chairman VOLKMER. Off the record—whereupon there was a brief off-the-record discussion.

Mr. GRIFFIN. For the record, let me introduce Joe Loftus who is the head of our technical planning office and spends much time thinking about the future, and that's why we turn to him in times when we need his guidance.

[Exhibit D–11.]

Mr. COVINGTON. The approach that this task force—and we are a part of this task force—has taken is we have a 3-year definition of planning where we're going to look at the technology and advanced development requirements, and then we are going to try to make the case that with the right application of that kind of work, up before a development program starts, that that would minimize the program's risk in terms of cost and schedule. We are using it, extensively, the use of in-house capabilities, and it's not only for the lack of funding, but because we think that's the right thing to do; it makes us smarter buyers; it makes us really able to know what it is that we ought to be asking for when we do go out with contracts.

We are assuming in this plan, for purposes of planning only, that there is some major funding in 1986 and 1987. We were beginning, thinking in terms of what we called a new initiative in 1986. I think now enough time has gone by now where we're saying 1986, 1987. These dates would go along somewhat with a launch date of the first elements in 1990 or 1991.

A rough cost estimate for an initial capability—and these cost estimates come from our administrator—is $4 to $6 million for an initial capability. And design the cost is not the right word, but plan the cost is sort of what we're doing in that line to see how we can fit an initial program into that particular cost level or funding level.

We are doing this program concurrently with the users, and they're very important to us. The study contracts that we do have now with industry involve getting out with the users and seeing what their needs are and what their participation would be, and really trying to make this a very user oriented, user friendly system. And it's wider than NASA; I think that's what we were talking about. In addition to all the centers in NASA being involved, there's several contractors who are participating in this with the Department of Defense; the science and applications boards are both working on it; commercial users are working on it; and there are four international—four parts of the international community are doing studies somewhat like this that we're sharing with you today on a no-commitment basis.

[Exhibit D-12.]

This is the way the task force is organized in three working groups. Missions, that's primarily what we're emphasizing now; systems; program planning.

[Exhibit D-13.]

On the next screen over here, you can see what the basic products of these working groups are. It's a set of mission description documents very much like the "Yellow Books" that were produced at the beginning of the shuttle program. As we probably see, they're having orange covers, so our "Yellow Book" is orange in the space station for some reason.

It doesn't have anything to do with Texas University, by the way. In addition to these working groups, at headquarters right now we're planning to install some sort of a concept definition effort that would be orchestrated from headquarters, but would be done by the centers that have to do with this trades management, trades synthesis, looking at preferred architectures and configuration options. That hasn't happened yet, but it's in the process right now of being formed.

[Exhibit D-14.]

There are these eight studies that I referred to that are going on. They having a value of $787,000 each. The ran from June 1982. Our final briefings are due at headquarters on April 4. They're going to make a tour through the centers here, and we're going to hear about it. Eight contractors: Boeing, G.D., Grumman, Lockheed, McDonnell Douglas, Martin Marietta, Rockwell, and TRW. The Department of Defense is participating in this and supplies a small amount of that funding. We had $8 million total for six contractors, and I think they added another $400,000, if I'm right about that.

Similar studies are being done by ESA, France, Germany, Japan, and Canada. And we're going to take the results of these studies with this working group that has to do with missions within NASA and synthesize the set of missions that we'll begin to do our architecture and design work from.

[Exhibit D-15.]

This is what we're showing in the task force right now for the architure of a space station. This is essentially what I was showing you awhile ago and calling a space station. This is the manned based part of it. It operates and interfaces with experiment modules that are added on to it to do this commercial experiment work that I was talking about. Logistics modules to resupply with. The support that's necessary for orbit transfer vehicles.

A lot of EVA crew operations, teleoperator maneuvering system work; could use the tether. And then the satellite support, the satellite services goes to platforms that could aggregate astronomical experiments or observation, the commercial work that has to do with Micro-G are scientific.

I think I'll stop there since time is going kind of slowly. I had a few pictures here to show you what one might look like, but I think probably it won't bother you.

[Exhibit D-16.]

This is a two-launch version of an early spacecraft, first space station. Some sort of a utilities power module that gives you regenerable power, radiators to reject heat, thrusters that control your attitude, large communications antenna to go through the TDRS, the track and data relay satellite to communicate with the ground and other spacecraft.

Now, one module here has docket ports on it that you can assemble from to grow as your needs dictate. Something like that would probably hold three or four people. A place for the shuttle to dock on when it came up. And the way you could add to that—and you really have to plan for where you want to go in order to know how to start. You can add another identical module, science module that could come on there to make things. We can begin to put on something that look like a surrogate payload bay there where you'd be able to simple stage this in to send off to other orbits.

This is a logistics module that we'd put 90 days of supplies in, use that up, put trash in, and the shuttle would come up and replace it. This represents a sheet metal unpressurized hanger to store an orbit transfer vehicle in. And the reason we'd have to put it in there is because of the debris problem we talked about a little earlier, and maybe you'd want to hear more about that sometime.

[Exhibit D-17.]

It could then draw on in into something like this as you just add more modules for more habitations.

[Exhibit D-18.]

And a configuration that would take six shuttle launches would look something like that, and it would hold about 8 people up there working—8 to 10 people. An artist's concept of it, done by one of these eight contractors, by the way, would say, "Well, you might put them together something like this with this utilities module and the habitations, the working areas, the control station, and this surrogate payload bay that would look to a payload just like the shuttle bay." So that's the kind of thing we're going to look like in size. It would weigh about as much as the orbiter. It would be about the size of the orbiter, but the internal volume would be considerably bigger than the orbiter.

Congressman LUJAN. It would still be using solar energy?

Mr. COVINGTON. Yes, sir, it would use some sort of regenerable power, because you wouldn't want to go through the operations of carrying up reactants.

Mr. GRIFFIN. Can I suggest about a 5-minute break and have some lunch, and then let George Abbey talk to us, while we're eating, about the astronauts.

[Whereupon a brief recess was taken.]

[Exhibits D–1 through D–18 of Mr. Covington's oral presentation follow:]

19-605 O—83——51

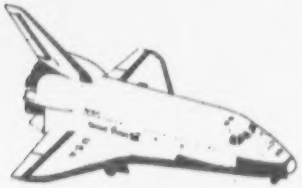
SPACE STATION ACTIVITIES

MR. COVINGTON

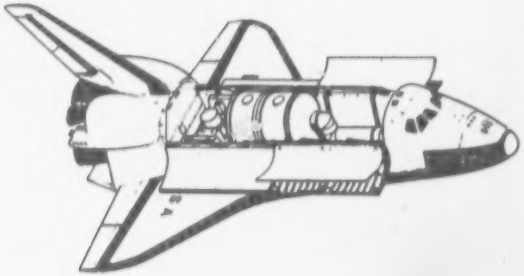
NASA

S-83-00489

The Space Shuttle Difference

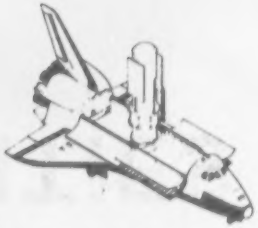


PRODUCT RETURN TO EARTH



ON-ORBIT MANNED OPERATIONS

LOW-COST SPACE OPERATIONS



LARGER PAYLOADS

NASA
5-83-00488

Shuttle Operational Design Limits

- PAYLOAD - 15-FT DIA X 60-FT LONG 65000 LB TO LEO
- CREW SIZE - 7
- MISSION DURATION - 7-10 DAYS
- MANNED OPERATIONAL REGIME - LOW EARTH ORBIT
- PAYLOAD TO GEO - 5000 LB (IUS)
  13500 LB (CENTAUR G-PRIME)
- ACHIEVABLE LOAD FACTOR/C.G. LIMITS
- GROUND TURNAROUND TIME
- QUICK REACTION TIME - LOAD, FUEL, LAUNCH TIME REQUIREMENT
- LAUNCH CONSIDERATIONS - WEATHER, LAUNCH WINDOW, ETC.

NASA

S-83-00483

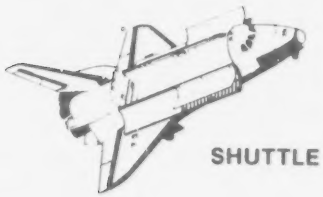
Space-Based Manned Operations

- GOALS CAN BE ACCOMPLISHED MOST EFFECTIVELY BY SPACE-BASING OUR SPACE OPERATIONS
- ACCOMPLISHMENT REQUIRES AN INTEGRATED SPACE OPERATIONS SYSTEM
- MAJOR SYSTEM ELEMENTS
  - SHUTTLE
  - SPACE STATION
    - MANNED
    - LOW EARTH ORBIT
  - REUSABLE ORBIT TRANSFER VEHICLE
    - UNMANNED - FLEXIBLE PAYLOAD CAPABILITY
    - MANNED
  - PAYLOADS
  - SPACE CREW

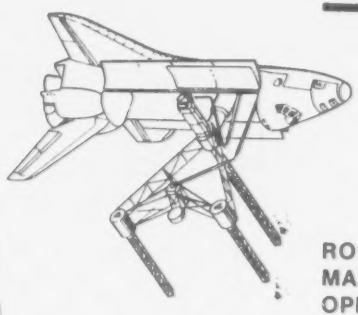
NASA

S-83-00485

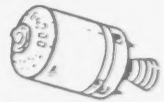
Space System Elements



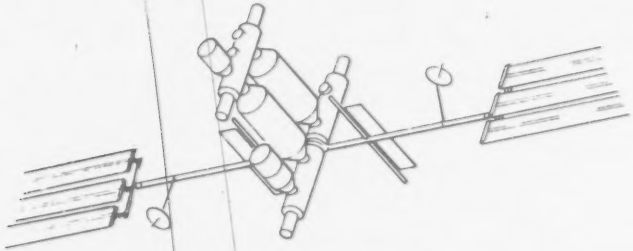
SHUTTLE



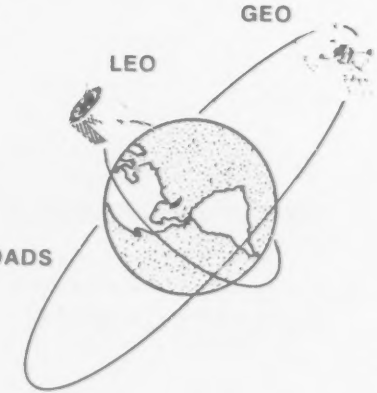
ROUTINE
MANNED
OPERATIONS



SPACE-BASED
ORBIT TRANSFER VEHICLE



SPACE STATION



NASA

S-83-00487

Space Station Concept

THE SPACE STATION CONCEPT IS A SHUTTLE-LAUNCHED, SHUTTLE-SERVICED, PERMANENT MANNED FACILITY IN LOW EARTH ORBIT FOR OPERATIONAL SUPPORT OF NASA, COMMERCIAL, AND DEFENSE SPACE ACTIVITIES

SS OPERATIONAL FUNCTIONS INCLUDE ...

- SERVICING OF SATELLITES AND PAYLOADS
  - ATTACHED PAYLOADS
  - CO-ORBITING SATELLITES
  - HIGHER ENERGY ORBIT SATELLITES
- LONG DURATION EXPERIMENTS AND PROCESSING
- SPACE AND LIFE SCIENCES
- EARTH AND NEAR EARTH OBSERVATION
- RESEARCH AND DEVELOPMENT
- FLIGHT SUPPORT OF SPACECRAFT
  - UNMANNED ORBIT TRANSFER VEHICLES
  - MANNED ORBIT TRANSFER VEHICLES
  - SHUTTLE
- SPACE CONSTRUCTION
  - ASSEMBLE AND CHECK OUT LARGE SYSTEMS
  - TRANSFER TO OPERATIONAL ORBIT

NASA

S-83-00500

Space Station Concept

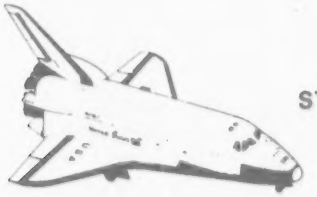
CONTINUOUSLY MANNED OPERATIONS FACILITY

- BASIC CORE CAPABILITY
  - HABITABILITY
  - LIFE SUPPORT
  - CONTROL CENTER
  - ELECTRICAL POWER
  - THERMAL CONTROL
  - DATA MANAGEMENT
  - COMMUNICATION
  - ATTITUDE AND ORBIT CONTROL
  - BASIC SAFETY AND SELF-REPAIR CAPABILITY
  - DOCKING/BERTHING INTERFACES
- ADD EQUIPMENT FOR
  - SERVICING NEARBY SATELLITES
  - SPACECRAFT ASSEMBLY - CHECK-OUT
  - SCIENCE AND ENGINEERING R&D MODULES
  - TECHNOLOGY AND COMMERCIAL MODULES
  - LARGE DEPLOYABLE SYSTEM C/O
  - SPACECRAFT/OTV INTEGRATION
  - PROPELLANT STORAGE
  - ON-ORBIT STORAGE OF P/L'S
  - COMMAND POST
  - SPACE DEFENSE SYSTEM ASSEMBLY

NASA

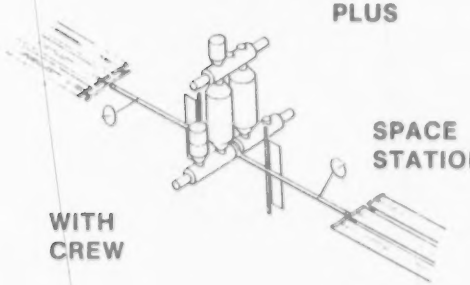
S-83-00482

Capabilities Summary



STS

PLUS



SPACE STATION

WITH CREW

ADD

SPACE BASED REUSABLE OTV

EFFECTIVE LEO OPERATIONS

- EXPLOIT SHUTTLE CAPABILITIES (LEO)
  - LOWER COST
  - PAYLOAD RETURN
  - ROUTINE MANNED SPACE OPERATIONS
  - SATELLITE SERVICE
- HIGHER ORBITS - UPPER STAGES
- SS BENEFITS
  - CONTINUOUS CREW/EQUIPMENT
  - MISSION TIME CONSTRAINT LIFTED
  - STS HIGH LOAD FACTOR
  - S/C CHECKOUT - RISK REDUCTION
  - PAYLOAD/STAGE SIZE LIMITS LIFTED
  - OPERATIONAL AND MISSION FLEXIBILITY

EFFECTIVE SPACE OPERATIONS

- PROVIDES LARGER PAYLOAD TO HIGH ORBITS
- LOWER GEO TRANSPORTATION COSTS
- PROVIDES CAPABILITY DEVELOPMENT FOR FUTURE MANNED GEO OPERATIONS
- FUTURE MISSION REQUIREMENTS FLEXIBILITY

NASA

S-83-00484

Program Approach

A SPACE STATION PROGRAM SHOULD ...

- PROVIDE INCREMENTAL GROWTH IN CAPABILITY NECESSARY
  - TO FOLLOW MISSION NEEDS
  - TO ALLOW COSTS TO BE SPREAD BY PHASING DEVELOPMENT
  - TO JUSTIFY EACH MAJOR PROGRAM PHASE ALONE IF REQUIRED
- DEVELOP PROGRAM INCREMENTS FOR MAXIMUM FLEXIBILITY TO ACCOMMODATE
  - YEAR-TO-YEAR BUDGET AND SCHEDULE CONSTRAINTS
  - PROGRAM REQUIREMENTS CHANGES
  - IMPROVING TECHNOLOGY
- BE DESIGNED WITH ELEMENT AND SUBSYSTEM MODULARITY TO ALLOW
  - LOW-COST REPLICATION
  - MISSION-SPECIFIC CONFIGURATIONS
  - HIGHER-ENERGY ORBITS
  - INDEPENDENT DEFENSE USE

NASA

S-83-00496

Space Station Task Force

- ESTABLISHED IN MAY, 1982 BY THE NASA ADMINISTRATOR
- NASA-WIDE ACTIVITY: CENTERS AND HEADQUARTERS
  - PROVIDE FOCUS AND DIRECTION FOR THE AGENCY'S SPACE STATION PLANNING ACTIVITIES
  - DEFINE POSSIBLE SPACE STATION INITIATIVE
    - MISSION REQUIREMENTS
    - ARCHITECTURAL OPTIONS
    - SYSTEM TRADEOFFS
    - ADVANCED DEVELOPMENT
    - PROGRAM MANAGEMENT
- DEVELOP MANAGEMENT/ACQUISITION PLANS

Mr. ABBEY. You're going to hear more about operations throughout the rest of the afternoon. On your tour, you're going to get a chance to see the shuttle mission simulator, which is one of our prime training facilities. You'll have an opportunity to get over to building 9A, which is where we have our mockup of the shuttle. We do a lot of training there. And then, of course, you'll have an opportunity to visit the control center where we actually control our shuttle missions, and then get to Ellington, too, to see our aircraft operations. So we're not really going to talk to you a lot about operations in that you're going hear a bit about that later on. Of course, one of the more visible parts of our operations activities is the astronauts. They are, in the final analysis, the ones who actually fly the vehicle; they fly the missions, and we're very dependent upon the crew, of course, to complete a successful mission.

We really reached a major milestone, I think, this month in that we announced the crews through the STS–13 flight and also two of the space lab flights, or at least a part of the crew for space lab 2, and the full crew for space lab 3. So we have actually 44 astronauts in training for specific flights at this time out of a complement of astronauts here in Houston of 77 astronauts. So better than half of the people we have are actually in training right now for specific missions. We really have within the complement in Houston a group of astronauts that came into the program in the 1960's, and they were around through the Apollo program, and a number of them flew on Apollo. They also flew on sky lab, and at least one of the astronauts flew on the Apollo-Soyouz mission.

Then we have another group of astronauts who came in when the MOL program was canceled in 1969. That was a DOD program, and we picked up a number of astronauts from that program who came to Houston in 1969. And between the older group and the 1969 group that came to us from MOL, we really made up the crews that flew the first flights of the shuttle.

[Exhibit E–1.]

We had another group of astronauts that we selected in 1977, and they came into Houston in 1978. We picked 35 astronauts in that group, 20 mission specialists and 15 pilots. The mission specialists, of course, are the individuals who do most of the activity on orbit, and their training and their backgrounds really limits them to the on-orbit activities. And the pilot and the commander are the two that really fly the vehicle, and they also assist in launch when we get up on orbit.

So we had 35 that came in in 1977—were selected in 1977 and came on board in 1978.

Then in 1979, we had another selection. We picked 8 pilots and 11 mission specialists, and that's the latest selection that we have.

[Exhibit E–2.]

These are some of the group—well, it's all the group that were picked in 1977 and reported in 1978. And, again, it consisted of 20 mission specialists and 15 pilots. And for the first time, of course, we had women entering the program. We had six women in this group, and as Jerry said in his statement, one of the first woman is going to fly here this spring on STS–7. Then we also assigned another women to fly on STS–12, which will be coming up in 1984.

[Exhibit E–3.]

NASA

S-83-00486

Space Station Planning
Definition Approach

NOW	LATER	SO THAT	LEADING TO
• TASK FORCE FORMED • TECHNOLOGY STEERING COMMITTEE AT WORK • NASA CENTERS ON BOARD • STUDY OF MISSION REQUIREMENTS UNDERWAY • PRELIMINARY SYSTEMS DEFINITION STUDIES BEGUN • MANAGEMENT APPROACH UNDER CONSIDERATION	• CONCEPT DEFINED • MISSION REQUIREMENTS WELL UNDERSTOOD • DETAILED SYSTEM DESIGN CARRIED TO SUBSYSTEM LEVEL • PROJECT, DEVELOPMENT AND FABRICATION, TEST AND OPERATIONS PLANS COMPLETED • MANAGEMENT PLAN IN PLACE • INDUSTRY TEAM SELECTED VIA COMPETITION	• SYSTEMS ARE WELL UNDERSTOOD • TECHNOLOGY AVAILABILITY IS RELIABLE • COST AND SCHEDULE ESTIMATES ARE DEPENDABLE	• INFORMED DECISION ON WHETHER TO COMMIT TO DEVELOPMENT PROGRAM

NASA

S-83-00493

Space Station
Planning Approach

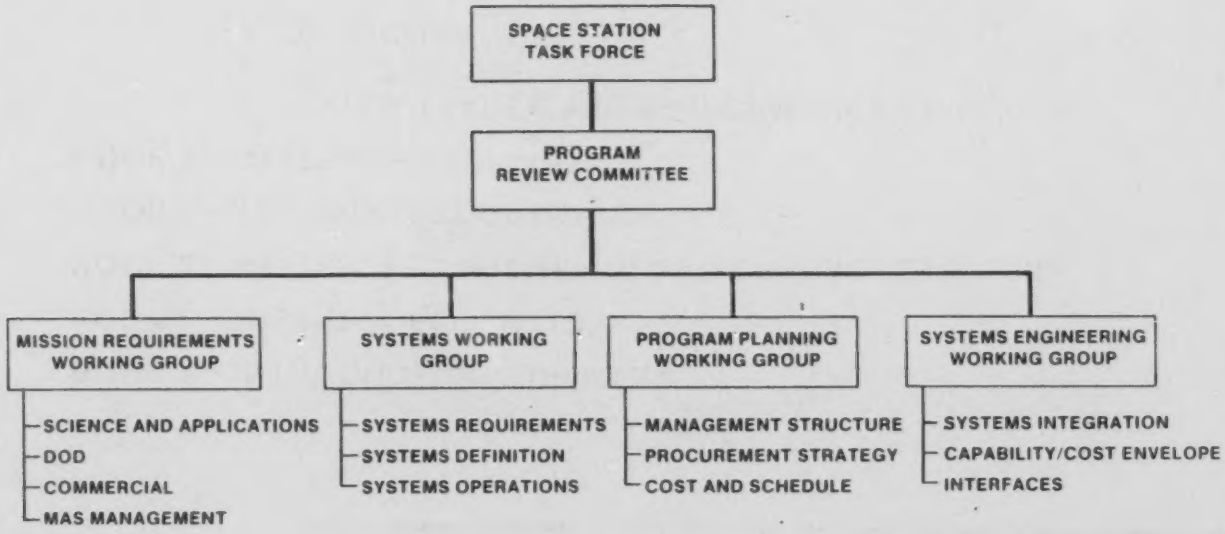
- THREE YEAR EXTENSIVE DEFINITION
  - TECHNOLOGY AND ADVANCED DEVELOPMENT FUNDING UP FRONT
  - EXTENSIVE USE OF IN-HOUSE CAPABILITIES
  - MINIMIZE COST AND SCHEDULE RISK
- ENABLES INFORMED DECISION ON SPACE STATION BY THE ADMINISTRATION AND CONGRESS
- ASSUMES MAJOR FUNDING IN FY 1987
- ASSUMES LAUNCH BY 1990/91
- ROUGH COST ESTIMATE FOR INITIAL CAPABILITY: $4-6B
- CONCURRENT USER PARTICIPATION
- WIDER THAN NASA
  - SEVERAL CONTRACTORS
  - DOD/USAF
  - SCIENCE/APPLICATIONS COMMUNITIES
  - COMMERCIAL USERS
  - POSSIBLE INTERNATIONAL PARTICIPATION

NASA

S-83-00492

Space Station Program Definition

Working Group Structure



NASA
S-83-00490

Space Station Program Description Documents
("Yellow Books")

BOOK 1. - INTRODUCTION/SUMMARY

BOOK 2. - MISSION DESCRIPTION

BOOK 3. - SYSTEM REQUIREMENTS AND CHARACTERISTICS

BOOK 4. - TECHNOLOGY OPTIONS

BOOK 5. - SYSTEMS DEFINITION

- **SYSTEM TRADES AND PERFORMANCE ENVELOPE**
- **ARCHITECTURE**
- **CONFIGURATIONS**

BOOK 6. - SYSTEMS OPERATIONS

BOOK 7. - PROGRAM PLAN

- **MANAGEMENT STRUCTURE**
- **PROCUREMENT**
- **COST/SCHEDULE**

NASA

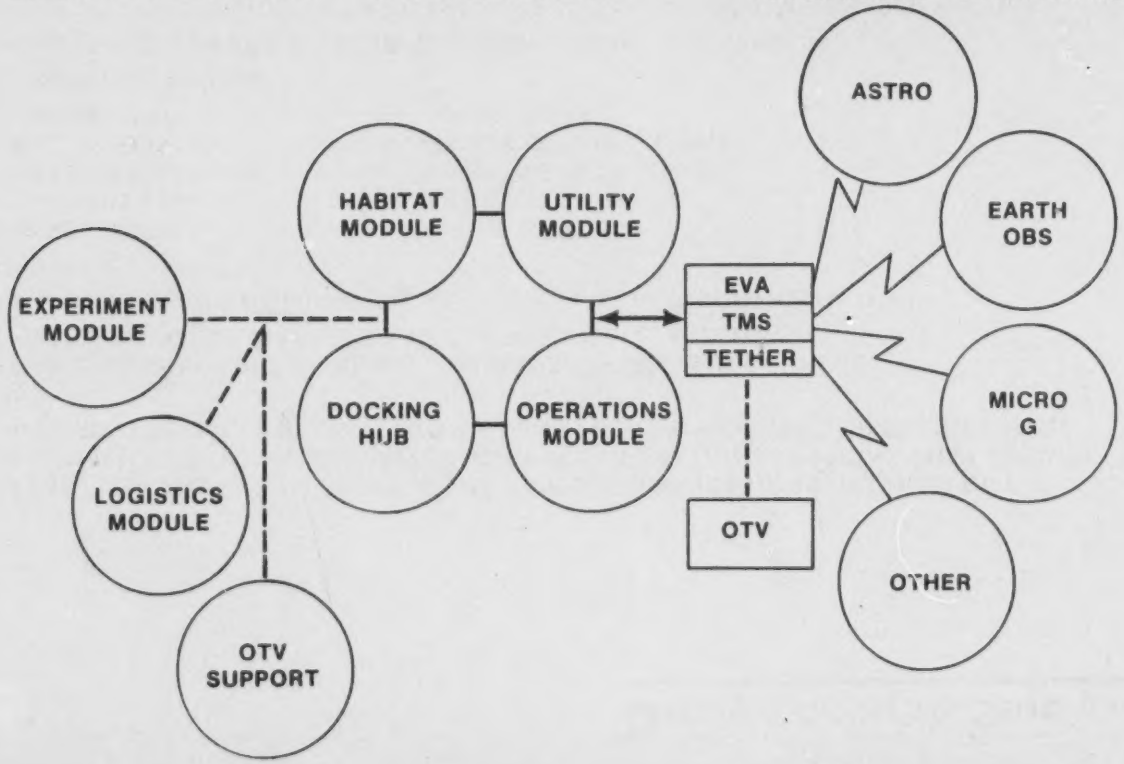
S-83-00491

Mission Analysis Studies

- EIGHT $787,500 STUDIES TO ANALYZE THE SCIENCE, APPLICATIONS, TECHNOLOGY DEVELOPMENT, NATIONAL SECURITY AND SPACE OPERATIONS MISSIONS THAT REQUIRE OR WOULD MATERIALLY BENEFIT FROM A PERMANENT SPACE STATION IN LOW EARTH ORBIT
- CONTRACTORS: BOEING, GENERAL DYNAMICS, GRUMMAN, LOCKHEED, McDONNEL DOUGLAS, MARTIN MARIETTA, ROCKWELL, AND TRW
- EMPHASIS ON USER COMMUNITIES. ARCHITECTURE NOT CONFIGURATION
- SCHEDULE
  - RFP RELEASED——JUNE 28, 1982
  - CONTRACTS SIGNED——AUGUST 20, 1982
  - MID-TERM BRIEFINGS——NOVEMBER 15-18, 1982
  - FINAL BRIEFINGS——WEEK OF APRIL 4, 1983
  - FINAL REPORTS——APRIL 22, 1983
- PARTICIPATION BY DOD
- SIMILAR STUDIES BY ESA, FRANCE, GERMANY, JAPAN, AND CANADA
- STUDIES WILL BE INTEGRATED BY NASA INTO SINGLE SET OF TIME-PHASED MISSION OBJECTIVES AND CORRESPONDING SPACE STATION REQUIREMENTS, FROM WHICH ARCHITECTURAL OPTIONS WILL BE DERIVED

NASA
S-83-00494

A Space Station Architecture
Cluster Concept



These are the pictures of the group that we selected in 1979 that reported in 1980. We picked 8 pilots in this group and 11 mission specialists. In this picture, we also show 2 Europeans that have been training with us; so actually we are showing you 21 people in this group. But this really represents that last selection that we had and the last group that we brought into Houston.

Looking ahead to the flight rate that we have to support during the coming year and the year after and then leading up to when we get up to 15 flights a year and then finally the 24 flights a year, we are concerned, of course, on having a sufficient number of crewmen to support that activity.

When we started back in 1972 and 1973 and looked at how many crewmen we had to have to support the mission models that we were expecting to be at that point in time, we were thinking that we could actually fly crews probably in the order of six times a year. I think now that we have a lot more knowledge abut the shuttle, how the shuttle is designed and we've trained crews to fly the first five missions and also almost completed our training for the sixth mission, we've got a better idea of what that training involves and really now long it really takes to prepare a crew to fly. Then also, I think, we have now in the design of the shuttle a better appreciation for the systems and just what the crew has to get involved in than we did 10 years ago. So I think now we're getting a little more realistic about how many times we can fly a crew. Six times a year, I think, was very optimistic. If you will look at, say, flight 6 where you compare and you have to take 4 months to prepare for a flight, say, 16 weeks, to fly three times a year, three times that would give you 48 weeks, and if you figure 2 weeks involved in the flight, you come out with 54 weeks. so to try to hit a flight rate of three times a year right now, I think, is probably very optimistic, and I don't think we can support it.

So as we look ahead to the future, I think we're looking at flight rates from individuals probably more in the order of two times a year. That's quite a difference from what we had expected, I think, early in the program. But I think the mission model and the number of flights that we're now expecting to fly in the near term, of course, has decreased. So I think that was a very fortunate turn of events for us, because I think as we got more realism into the flight rate as far as the crews go, the mission model and the number of flights decreased, and fortunately, it looks like they're kind of matching up pretty well.

But in any case, as we look ahead to the time period of 1987, 1988, we're concerned about supporting flight rates at 24 flights per year with the present group of astronauts. We have, as I say, 77 people in Houston today, and out of that group, we have 12 pilots and 11 mission specialists, for about 23 people of the older group prior to the 1978 group. So I don't think it's very realistic to expect them to be around and flying during the 1987 and 1988 time period. So looking ahead to the attrition we expect, they will probably not be around.

[Exhibit E–4.]

We also have, I think, a fairly good leadtime on preparing—once we select an astronaut and bring him into the program, we have a fairly good leadtime on preparing him for a flight. If we select indi-

viduals, say, in 1983, if we do have a selection—which we really haven't made up our minds to go ahead with it yet—but if we did have one, we have an astronaut candidate program where we select an individual, he comes to Houston, he goes through a training program, and we look at the individual on a variety of different jobs, and he goes through a basic training course, and that takes a year. And at the end of that year, we're ready to determine whether he would then stay in the program and become an astronaut or not. That takes about a year. When we started with the 1978 group, we were scoping that to be 2 years, but now we have, I think, realistically reduced that to 1 year.

In addition to that, we have an opportunity to look at the individual on the job in a variety of tasks for over a period of a year and a half—year and a half to 2 years. And at that point in time, I think we have a fairly good knowledge about his capabilities, and we could then move him into a flight assignment.

For a first time flight assignment, it takes about a year to prepare for a flight. It might take a little less as we get more knowledge and, I think, get our program a little further along. But if we bring people in—select them in 1983 and actually bring them to Houston in 1984, you're really looking at people who wouldn't really fly for about 3½, 4 years. And that would put you in the 1987–1988 timeframe. At that time we're really having to support a flight rate of about 24 flights per year.

[Exhibit E–5.]

So if we did go ahead with a selection this year, we're really at the point now where we'd have to make that kind of a decision, and we've been discussing that with NASA Headquarters. But if we did go ahead, we would probably announce in the fall—come out with a NASA announcement about the selection. Because of the leadtime involved with the military services, in that the military services usually provide us a number of candidates, they would like to have their announcement go out earlier in May of this year for a selection this year. And then we would make a selection in early 1984 and give individuals the fall until the end of the year to get their applications in. And the military, of course, runs their own selection program. Each of the services has their own selection board, and then they pass their nominees on to NASA, and then they become integrated into the selection that we would do in the first part of 1984. Then that group of individuals that we selected would come in July of next year, and they then would provide us with new people that we would want to fly in the 1987 and 1988 time period.

[Exhibit E–6.]

At that point, looking at the group that we selected in 1978 and in 1980, we have a substantial number of military officers in that group. When we started out in 1978 with that group coming to Houston, we had commitment for that military group of astronauts to be assigned to NASA for a 5-year period with two 1-year extensions. We have at least a verbal agreement that would allow the military to extend that commitment for 2 more years, and if we don't get that kind of a commitment from the military services, of course, I think we're really probably going to have great difficulty making the flight rate that we have to in 1985 and 1986. But as-

suming that is a firm commitment, the 1978 group will be here with us until 1987, and then the 1980 group would be staying with us until 1989.

We're in the process now of talking to the military about a possible selection this year, and I think we'll try to stay with a commitment from the military at 7 years; that's a five plus a two 1-year option. But I think at least in this 1980 time period, to get us over this problem area in 1985, 1986, and 1987, we would like to extend that for them for at least 9 years.

[Exhibit E-7.]

There's been a lot of discussion about the way we would conduct a program. In the past selections, we have very large selections of people; as I say, we picked 35 in 1977, and we picked 19 in 1979. And really, that kind of a selection program, I think, is not too efficient for us and probably not too efficient for the individuals who are applying.

So what we've been talking about going to is an annual selection program where individuals on the outside could then gear their careers and decide relative to that of getting experience and getting the academic background to qualify them. They could gear that to a selection program that they knew was going to go on each year, and they would be in a better position, I think, from their careers, and I think we would be in a better position if we had the annual program so we would then select as many as we might need during any one year. So if we needed two or three people, we'd select two or three people. If we needed five people, we'd select five people; and we'd have more or less a register of people that we'd update on a yearly basis. And then we'd be able to select candidates much like we do other employees here coming to work at Johnson Space Center.

I think that would be a much better situation for us and a much better situation for the applicants that are applying to get into the program. So hopefully, we're going to be able to go to that kind of program in the future.

We'd also have the benefit, I think, of having the new college graduates or people that have gotten recent training and experience coming into the program, as Jerry said earlier; and I think that would be a very healthy thing for our astronaut program, because I think we have seen the effect of not selecting crewmen on a more regular basis, and that has frankly impacted not only the design of the shuttle and the design of the vehicles that we've done in the past few years, but I think it has had an impact on the training program. So I think as we get new people to come in on a regular basis, that's probably going to be good for the whole program. I think that having their experience and knowledge—because technology is changing so quickly—that it's important to have people that have backgrounds and experience with the aircraft that are being developed today, because that technology, I think, has really taken major strides forward in the last few years.

The data of this flight, for example, that we have flying for the first time in this upcoming flight is a good example of that. That was state of the art in aircraft, I think, during the 1970 time period. We moved it into the shuttle program not in time to make the first few flights, and now it's going to be flown on STS-6 for

the first time. That's going to provide us a much better aid for landing the vehicle, and I think it's going to help train crews, cut down our training program, and make that go much quicker as far as being an astronaut prepared for flight. So those kinds of things, I think, are going to be important in the future, and I think the annual program and having people that have recent experience, recent flight testing, and recent flying experience coming into the program on a regular basis would be the right thing to do. So that's kind of where we're going in the future.

Congressman LUJAN. When they leave, do they leave generally of their own volition or because it's NASA policy?

Mr. ABBEY. Well, we have had astronauts leave for a variety of reasons. A number of astrouants have been in the program for a long period of time, and they wanted to stay with us in order to get a flight or to get flight in the shuttle, and I think some of the crew members that we've flown will probably be leaving us in the coming months and years after they've flown a couple of times. I'm speaking now of the pre-1978 group. And they're still young enough where they can go into other careers, and I think that they feel that they've spent a good bit of time involved with this kind of business and they want to go off and do other things. Al Bean, for example, left us last year. Al has always wanted to be an artist, and he decided that if he was going to be an artist, that he'd really have to move off and do that. So he decided that was a career that he wanted to follow, and he went off and did that last year.

We've had other astronauts that have had opportunities to go into industry. We've had astronauts—not a lot—go back in the military service. I would expect probably in the new groups, the 1978 and 1980 groups, and with the military involvement that we're seeing in the space shutte, that there's going to be opportunities within the military services for those military officers, and they're going to have an opportunity to go back and get into the space activities in their respective services. So I think we're going to see officers going back to the military, and I think that's good for them and good for us.

Mr. GRIFFIN. Let me amplify his answer a little bit, too. We've never had a situation where we had this operational system, so to speak, a recurring or repetitive year-after-year kind of thing. And th exact answer to your question is that people have left when they were—of their own volition. The other reason that you could postulate: that they might leave because of medical reasons. We have had essentially none of that. In fact, I don't think we've had any.

But I think the day is coming when the turnover is going to be more predictable. I think people are—as George says, for instance, the military people are going to be asked by their services to return and not be extended forever. We've got some military people here that have been here since the mid-sixties; so they've essentially made a career of NASA.

We've got people in the program prior to 1978 that are just now getting the chance to fly, but they've been in the program for 16 years—16, 17 years. Obviously, with the 1978 group and the 1980 group, that's not going to happen. These people will get on with it, they'll make a career decision based on—like the rest of us have; that is, if we decide that we've done something long enough, and

they want to go do something else. So I think we are going to see a more viable force that needs to be limited on a somewhat regular basis and not in these large gulps of 35 and 20 people at a time.

For instance, George has said one thing. In looking at mission model, it appears that at about this 80 level, about 40 pilots and about 40 mission specialists, is about where we want to stay. Now, we may adjust that some. So what I perceive is when people retire or quit to go make their fortune or whatever, in any 1 year we can just replace the number to keep our cadre at about the same level, around that 80 number. And I think that's a much healthier way of doing it than trying to predict, which is virtually impossible to know exactly what the attrition is going to be.

Now, the reason we're still a little edgy about this year, whether we want to go with it, is there are some differences of opinion between us and some of our headquarters people about what attrition we think that we ought to see. So I'd say it's a relatively close call, whether we need them this year or next. My personal opinion: I think we need them this year.

Chairman VOLKMER. How many would you be talking about this year and 1984?

Mr. ABBEY. Oh, probably in the neighborhood of about half a dozen.

Chairman VOLKMER. Each? Total?

Mr. ABBEY. Well, total, probably; and as Jerry says, I think we have to adjust that as we see the attrition. We've got some predictions on attrition of people that are probably going to go off and want to do other things, and that would be a factor that would probably decide us on what the numbers would be.

Congressman LUJAN. And then you've got the military problem, too.

Mr. ABBEY. Yes.

Congressman LUJAN. It's been 7 years coming up, and they're probably going to be leaving.

Chairman VOLKMER. Do they get paid just a regular military pay?

Mr. GRIFFIN. Yes, sir.

Chairman VOLKMER. Is it possible that some of those people who have been here since 1977 and 1978 will not get up on the shuttle?

Mr. ABBEY. Oh, no.

Mr. GRIFFIN. I don't think so.

Congressman ANDREWS. Do you think they all will have an opportunity to fly?

Mr. ABBEY. Now, just to give you an idea, I said there were 44 people in training for a flight right now. Out of the 35 that we selected in 1977 and reported in 1978, 23 of those people are training for flights today. So out of that group in 1978, there's only 12 that have not yet been assigned to a flight, and probably before the summer is out, all of those 12 will be in training.

Mr. GRIFFIN. We'll probably be into the 1980 class by then.

Congressman LUJAN. They'll be assigned, but how far out?

Mr. ABBEY. We'll probably have the additional 12 assigned by this summer and they'll have flown by next summer. So they're about 1 year—a little over 1 year now away from their flights.

Chairman VOLKMER. What you're telling me then is that you fly once and you're not going to fly a second time.

Mr. ABBEY. Oh, no; we've got two people out of the near term group—well, Bob Grippen is a good example. Bob is now coming up for his second flight this spring. He's already been announced for a crew to fly next year, and we've already tentatively identified him for a flight that same year already; so we're already going to probably hit at least on Bob two flights per year. We have two other individuals—one on 7 and one on 8—that also were in the last announcement that we just made, and they're going to be flying their second flight. So we're cycling people back, and we really have to do that to support the missions that we're going to be flying next year.

Chairman VOLKMER. So you do not foresee having any surpluses of astronauts and the technical people in the 1984 year?

Mr. ABBEY. Not at all. When I say that we have 44 people training for flight, we have a number of other jobs that these people do for us, like the Capcoms in the control center; the crewmen do those jobs. We have testing activity going on at the cape; testing activity in the shuttle avionics integration lab, testing at Downey. We have a lot of design and development activities. We're trying now to work with the remaining 33 people we have to try to cover all those activities. So the flying part of it is the more visible to people, but they do much more than that.

Chairman VOLKMER. I recognize that.

Congressman LUJAN. Well, that's what they're here for.

Mr. ABBEY. That's right. But when I look at being short of people, at this point in time, I would have to say certainly there's no surplus of people. You could probably find people that say we're short right today.

Congressman LUJAN. That's what I was getting at. Again, going back to that GAO report, you'll find things in that GAO report that are according to their figures.

Mr. ABBEY. They've been talking to us. They've been with us now for the last couple of months, and I think they are updating that report, and I think we're getting a little better deal for what kind of——

Chairman VOLKMER. In other words, you're adding more than two people to a flight, too. You're going four and eventually up to six.

Mr. ABBEY. That's right. We talked earlier about getting up to six on a flight. We have five on flight 7; we have five on flight 8.

Congressman LUJAN. Now, out of those, only two or maybe three at the most will be actually astronauts?

Mr. ABBEY. All five are.

Mr. GRIFFIN. On these flights.

Congressman LUJAN. On these flights they all are? They're all pilots?

Mr. ABBEY. No; its a breakdown between the pilots and mission specialists. On flight 7 we have two pilots and three mission specialists. On flight 8 we have two pilots and three mission specialists. On flight 9 we have a total of six people; four of those are astronauts. On flight 10, which is a DOD flight, we've announced four

individuals. Flight 11 we have five astronauts. Flight 12 we have five astronauts.

Mr. GRIFFIN. Plus, we're looking at a CFES in our specialists.

Congressman LUJAN. But getting back to the question of the surplus of the pilots themselves, you do not have an overabundance of pilots?

Mr. ABBEY. We need on each of the flights two pilots. We have 35 pilots within the group we have. Of that group, 12 of those are pre-1978, and that means that we really——

Congressman LUJAN. You've got 23.

Mr. ABBEY. We have 23 pilots to support all our activities.

Congressman LUJAN. So that's 11½ missions one time around.

Mr. ABBEY. Right.

Congressman LUJAN. That's more than you're going to have these next 2 years.

Mr. ABBEY. No; we're going to hit 10 flights per year in 1985, and you figure——

Congressman LUJAN. But I mean 1983 and 1984.

Mr. ABBEY. In this coming year, we've got five flights. And then we go up and build up to 10 and then we go up 24.

Congressman LUJAN. But in 1985 is when you might run into problems?

Mr. ABBEY. We can cover it certainly through 1984 with 10 flights. I think we've got crews to cover that from the 1978 and the 1980 people and some of the older people.

Congressman LUJAN. But by 1985 you're going to lose a couple of those people?

Mr. ABBEY. Unless we can extend, as we understand the military has agreed to do it, at least verbally—extend them for 2 years. If they don't do that, then we have serious problems in 1985.

One of the other problems, I think, we're starting to run into, which is what you'd expect probably is not—we should have expected that to happen, but we now have, I think—we're running into the same kind of problem the airlines and all the other people have relative to ages of crewmen. If you look at the pre-1978 group, they're getting up in years and there's a retirement age, I think, within the airline industry for pilots; but that's certainly getting to be a factor. It's getting harder for them to pass physicals every year, and that's an element I think is going to affect how many crewmen we're going to have available.

Chairman VOLKMER. You talk as if they're old man.

Congressman LUJAN. Some of them are around 50 or more?

Mr. ABBEY. We have them older than that. We have probably in one of the men that we announced, by the time he flies, he'll probably be 57 or 58.

Mr. GRIFFIN. He's a mission specialist, not a pilot.

Congressman LUJAN. What's the average pilot age?

Mr. ABBEY. We have a number of pilots that are over 50.

Mr. GRIFFIN. John Young.

Mr. ABBEY. John Young, Vance Brand—Vance flew the last flight and is now scheduled to fly flight 11. He's over 50.

Chairman VOLKMER. Just observe how many of them will have to wear their glasses when they fly.

Mr. ABBEY. That's getting to be more the normal—seeing pictures of astronauts in flight, that's going to be more the normal.

Mr. GRIFFIN. Let me put a cap to this. With the timing of this hearing, we're right in what I would call the final determination of how we are going to handle this astronaut program for the longer haul. We have got a lot of discussion going on with the folks at headquarters. We think we have a system design now where we can do this annually; at least we designed it in principle where we can do this annual augmentation and not bring in these large, huge spaces but kind of have it, like George said, more like we do other jobs in the space business, where we keep a register of people and update it; and then when we need to go to it, we go to it and pick off the top two, three, four, half a dozen.

I think by the time—in fact, I suspect Lieutenant General Abrahamson may discuss this with you when he has you. He may have some more solid answers for you by the time Lieutenant General Abrahamson testifies for you. But if he doesn't, within the next 2 or 3 weeks, I think we'll have this thing pretty well geared together; and I would suggest that we let you know how it's coming along.

Chairman VOLKMER. You want to keep it at a number of 80, right?

Mr. GRIFFIN. On that order. It may vary a little bit.

Congressman LUJAN. That's the combination of mission specialists and pilots?

Mr. GRIFFIN. And pilots.

Mr. ABBEY. I think there are a large number of people that want to participate in the program. I think that's one of the gratifying things to us, is that in each of these last two selections the outstanding—the really outstanding people are applying to get into the program, and it makes it very easy for us because there are so many outstanding people who want to participate; and I think having an annual selection really helps them plan their careers because they're all doing very interesting things and are involved in very interesting activities; and if they knew there was a selection each year, they'd have an opportunity to apply for it. It would really be a big help to them.

Congressman LUJAN. What is the average age of your incoming group in the eighties?

Mr. ABBEY. Of the 1978 group, the youngest that we selected was 26 years old. And probably the oldest we selected in 1978 was 38. In the 1980 group, probably the youngest was 28 and the oldest was around 35.

Mr. GRIFFIN. Are we ready to adjourn and start the tour? Thank you very much.

[Exhibits E-1 through E-7 of Mr. Abbey's oral presentation follow:]

ASTRONAUT SELECTION BRIEFING

822

MR. ABBEY

ASTRONAUT SELECTION PROGRAM

ASTRONAUT CANDIDATES
SELECTED JANUARY, 1978

Thirty-five new astronaut candidates

RECENT SELECTION HISTORY

- SELECTION IN 1977
  - 15 PILOTS
  - 20 MISSION SPECIALISTS
- SELECTION IN 1979
  - 8 PILOTS
  - 11 MISSION SPECIALISTS

ASTRONAUT CANDIDATES
SELECTED JULY 1980

NASA

TRAINING PROGRAM

- ASTRONAUT CANDIDATE PROGRAM - 1 YEAR
- ADVANCED TRAINING AND ON-THE-JOB TRAINING (CAPCOM, TEST AND DEVELOPMENT, ETC.) 1 1/2 - 2 YEARS
- SPECIFIC FLIGHT TRAINING 1 - 1 1/2 YEARS
- 3 1/2 - 4 1/2 YEARS UNTIL INDIVIDUAL ACTUALLY FLIES

1983 SELECTION PROGRAM

- ANNOUNCE FALL 1983 (CIVILIAN)
- MILITARY ANNOUNCE MAY 1983
- SELECTIONS MADE EARLY 1984
- ASTRONAUT CANDIDATES REPORT JULY 1984
- WOULD FLY 1987 - 1988 TIMEFRAME (FLIGHT RATE ≈ 24 FLIGHTS/YEAR)

828

19-605 O—88——53

NASA/MILITARY COMMITMENT

- 7 YEARS
- PRESENTLY ASSUMING TWO YEAR EXTENSION
- '78 GROUP - COMMITED TO 1987 (20 MILITARY)
- '80 GROUP - COMMITED TO 1989 (13 MILITARY)

FOLLOW-ON PROGRAM

- WOULD PROPOSE GOING TO ANNUAL PROGRAM
- SELECT AS MANY AS MAY BE NEEDED IN ANY ONE YEAR

FIELD HEARINGS

SATURDAY, FEBRUARY 26, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APLICATIONS,
Martin Marietta, Michoud Division, New Orleans, La.

CHAIRMAN VOLKMER:

The Subcommittee is currently reviewing the NASA (National Aeronautics & Space Administration) fiscal year budget request and the briefings and discussions today become a part of our final hearing record.

I am pleased to have the full committee chairman, Representative Fuqua with us. He is out right now, but he will be back in a few minutes and join us for the hearing. I appreciate you all taking the time on a nice Saturday morning to be here with us, and at this time I would like to recognize the ranking minority member, Mr. Lujan, from New Mexico who is with us.

REPRESENTATIVE LUJAN:

Thank you, Mr. Chairman. I don't have a statement. It is just nice to be here. It never ceases to amaze me the type of organization it takes to do just one part of the whole shuttle, although the most important part, but really, it is just amazing how you folks can bring all of these things in together and achieve this great end result.

It takes a lot of organization and I am pleased to be here and look forward to checking you guys out and seeing how those tanks are coming along.

CHAIRMAN VOLKMER:

At this time I will recognize Mr. Odom for the purpose of making his presentation.

STATEMENT OF MR. JAMES B. ODOM
DEPUTY MANAGER, PRODUCTION AND LOGISTICS
SHUTTLE PROJECTS OFFICE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS OF
THE COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES
FEBRUARY 26, 1983

MR. ODOM:

Mr. Chairman and Committee Members and visitors, we would certainly like to welcome you to the Michoud Facility and on behalf of Dr. Lucas and Bob Lindstrom who is in charge of our total shuttle program at Huntsville. We certainly are pleased to present to you a discussion of our program today, and take you on a tour to give you a feel for where we are in this part of the program.

We are certainly pleased with the progress that has been made here and look forward to many more years of producing the tanks at this facility.

We believe that we have responded to the items of interest that you have indicated and if we have not then feel free to ask questions and we will provide any additional information that you may want.

I would like to, at this time, turn it over to Dr. Siebel who will introduce the NASA people and give you a brief Facility overview and then we will go right on into the Martin presentation. Mr. Timmons will introduce the Martin people, give a presentation and then we will tour the Facility.

If there is any information that we can provide for you while you are here, feel free to call upon us. I am going to turn it over to Dr. Siebel who is our NASA manager of this Facility.

STATEMENT OF DR. MATHIAS P. SIEBEL
MANAGER, NASA/MSFC MICHOUD ASSEMBLY FACILITY

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS OF
THE COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES
FEBRUARY 26, 1983

DR. SIEBEL:

Mr. Chairman and members of the committee, I am glad to see you again this morning and add my welcome to Jim Odom's.

I will give you an overview of this facility, which is a Government owned facility, but before I do so, I would like the opportunity, with your permission to introduce the NASA folks who are here.

There are also, of course, a large number of Martin folks and Mr. Timmons will introduce them.

Mr. Hill is the resident External Tank manager. Mr. Bridwell is the Deputy Manager for the tank project in Huntsville.

Mr. Weeks, of course, you know from NASA headquarters. Jim Odom, Mr. Coldwater, Mr. John Taylor and Mr. George Hobson are all from the Marshall Space Flight Center in Huntsville. Ed Williams is my deputy here. In the back is Mr. Demerest, Mr. White and they are both local people supporting the plant on site.

Now, to orient you about our situation here, (Figure 1) we are a part of the major NASA activities in the region. The NASA National Space Technology Lab (NSTL), located near us, is a center itself, and is the location where the hazardous testing on engines and also on tanks is accomplished.

We don't do any testing on site. The testing is done at NSTL and they are also engaged in many other activities.

It is a very large site with a large buffer zone located mostly in the State of Mississippi. In Slidell is the computer complex which supports to some extent the Marshall Space Flight Center, but about 95 percent of its capacity is dedicated to supporting Michoud.

Michoud is located here. This is where you are right now. This is where you spent the night in New Orleans. New Orleans stretches from about here all the way to over here, and you can see that the eastern part of New Orleans is not very developed, and we are sort of a role model of industrial development in the area.

Now to come specifically to Michoud, Michoud, as you see. . .

REPRESENTATIVE LUJAN:

Let me ask you before you move further. What relationship is there between the space lab and the computer complex?

DR. SIEBEL:

Between the NASA Space Technology Lab?

MR. WEEKS:

In Slidell, I think he means.

DR. SIEBEL:

Yes, in Slidell. Yes I think they draw a little bit of support but essentially none.

MR. ODOM:

The NSTL is a separate NASA installation. The Slidell computer facility is owned and operated by our Center; it supports the NSTL.

REPRESENTATIVE LUJAN:

You mean by Marshall?

MR. ODOM:

Marshall, that is correct.

REPRESENTATIVE LUJAN:

Okay. You were talking about them in the context of relationship to Marshall rather than to Michoud, is that correct?

DR. SIEBEL:

Yes, but also I think I said two things, and I said it perhaps too quickly. Slidell is another component facility of the Marshall Space Flight Center. It is a computer complex and the dominant work load at Slidell comes from Michoud and supports the tank.

The Facility itself, (Figure 2) the Michoud Facility, is roughly, very roughly, triangular. It is bounded on two sides by water. You can see the Mississippi in the background here.

This is the Mississippi. This is the Intracoastal Waterway. This is the Mississippi Gulf Outlet. This is a canal which deadends here and the road along which you came.

The Facility itself (Figure 3) has quite a large number of buildings. When it was acquired by the Government, it was intended originally for ship construction, Liberty ships in World War II, but that never came to pass, and it was ultimately built for aircraft production.

But before that could really be, the War was over and the Facility was mothballed. In fact, if I can relate the buildings to the period, this major 43 acres under one roof building was built for aircraft production. These long narrow buildings in the front were the engineering and administration buildings.

In addition, there were some support buildings around. For example, this hangar, and you can also see the old traces of the runway. This was the main runway, and there were some other buildings, like a boiler house, that were built at the time.

The Facility was reactivated during the Korean War; Chrysler built tank engines here and to test them they had a test cell which is this building, 111, - it is now used for storage.

Then came along the space program and this site was particularly attractive to the space program, because as you will see it has enough height under the roof and enough spacing between the columns so that we can build large space vehicles. Also, we have the ability to ship them by barge to wherever we need them, which might be to Huntsville for testing, or to the Space Technology Lab (which was the Mississippi Test Facility for engine firing or hazardous testing). We can also ship them to the Cape for launch and, ultimately, to Vandenberg for launch from the West Coast.

We have water access to wherever we need to go. So this plant site became very attractive and we built here the first stages of the Saturn I Class vehicles and also the Saturn V Class vehicles, and we had two contractors at the time: essentially Boeing had this half for the Saturn V first stage and Chrysler had that half for the Saturn I first stages.

At that time buildings were added. For example, the high bay area was added for the welding and assembly of the S-IC, the first stage of the Saturn V. This office building that you are in right now was added. The check out cells were added and several other buildings.

So it is almost like a tree with rings, the age of the facility. As new programs come along, we add appropriate buildings.

In '73, Martin was the successful bidder on the External Tanks for the shuttle program and the plant again has been modified, is in

the course of modification. This high bay area was added, and the pneumostatic test facility, and of course, there were quite a few modifications within the buildings.

We also have to maintain what is popularly called the infrastructure. There is a lot of infrastructure here. We have a major air conditioning plant. We have major drainage problems, parking problems, guard plant engineering type activities.

So you may as well see this. This building was also added. It handles things like medical services, transportation and reproduction services, and security.

At the peak of these programs, there were about 12 or 13 thousand people on site. Our current strength, as I will show you later in more detail, is about six thousand, so the space that became available, particularly in the interim between these programs was put to good use by making arrangements with other Government departments for cost sharing - the space available generally is not manufacturing space but is office space, and Agriculture, the dominant tenant, occupies about one-third of the building we are in right now.

These are some statistics (Figure 4) on the building that we have here. The dominant building, of course, is this major building dating to World War II, which has 43 acres under one roof, and is part of this 56 acres.

We draw our computer support, as I already mentioned, from the Slidell Computer Complex and we have access by water and we have a port here.

The staffing (Figure 5) currently is about 4500 Martin employees with their subcontractors. We have a Government force dedicated to the tank program of 140 or so. NASA has about 33 employees and that encompasses people responsible for the tanks, for the facility, for quality and for engineering, and so we have a small but diverse staff here.

We have delegated quite a few functions to the Department of Defense. The Defense Contracts Administrative Services provide property functions, contract functions and, most importantly, the quality and reliability functions for us. We also have some folks from the Defense Contract Audit Agency who work on the contract side, of course.

As regards the tenant agencies we have, as I mentioned, the National Finance Center of the Department of Agriculture who are our dominant tenants.

We have a small Navy lab. We have some other Defense Contracts people who are conveniently located here but work contracts other than ours and therefore contribute to the cost of running the place.

We have the City of New Orleans. There are two people here and they are the Almonaster-Michoud Industrial District people who worry about the development of the Eastern part of New Orleans and try to make it attractive to industry.

We work quite closely with all of the industrial development people in the region to serve as a role model and to discuss with them labor availability and that type thing, and that, essentially, is our population.

You will see in summary that roughly three-quarters of the

population, a little over three-quarters is External Tank related and one-quarter, in rough numbers, is tenants.

That is the end of my presentation, unless you have some questions.

REPRESENTATIVE LUJAN:

What other programs does Martin Marietta have? You have 98 people there through other programs.

MR. TIMMONS:

We have two other study contracts with the Marshall Space Flight Center and we are doing all new business acquisition and expenditure work and funding for future studies - the intention being to find a suitable job in the future for the people who have been rounded up here as the high technical content of the labor force, and we would like to continue to keep that group working here in the future on things like the external tanks, and its potential uses, Mr. Chairman.

[Figures 1-5 of Dr. Siebel's oral presentation follow:]

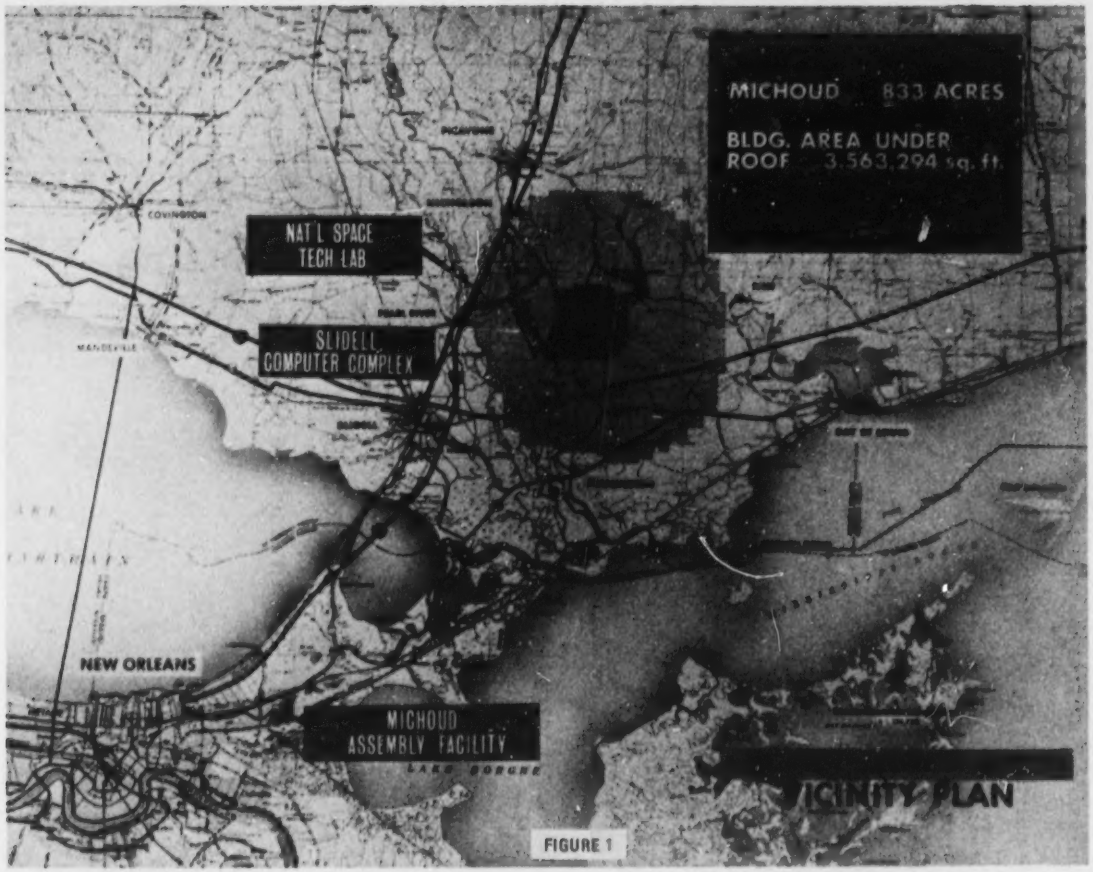

MICHOUD 833 ACRES
BLDG. AREA UNDER ROOF 3,563,294 sq. ft.
NAT'L SPACE TECH LAB
SLIDELL COMPUTER COMPLEX
NEW ORLEANS
MICHOUD ASSEMBLY FACILITY
VICINITY PLAN

FIGURE 1

MICHOUD ASSEMBLY FACILITY
PORT MICHOUD
MARCH 1987 PHOTOGRAPH

FIGURE 2

STATEMENT OF MR. KENNETH P. TIMMONS
VICE PRESIDENT AND GENERAL MANAGER

MARTIN MARIETTA, DENVER AEROSPACE, MICHOUD DIVISION
FOR THE

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS OF
THE COMMITTEE ON SCIENCE AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES
FEBRUARY 26, 1983

MR. TIMMONS:

Chairman Fuqua, Represenative Lujan, ladies and gentlemen, I am Ken Timmons, Vice President and General Manager of the Michoud division of Martin Marietta Aerospace.

To make sure that we have answers left over, today when the questions are exhausted, I have brought the people here who designed and build and buy and inspect and control and take care of the facility.

Starting at the end is Jimmy Hughes, who runs our procurement operation. Art Welch, quality reliability and safety. Bob Hieter is the man who produces the tanks. Bob Smith in charge of the development work. The man who runs the program, Ric Davis, and representing Randy Tassin we have Phil Catarella in the back of the room who does the facilities work, and that is the resource for the questions and answers.

To start with, "assembly" is the middle name of this Facility - it is the Michoud Assembly Facility. We buy throughout the United States and on the facing page (Figure 1) in the handout, you will see the documented information that also is being submitted for the record, but we buy all over the United States.

The major structural components (Figure 1) which are put

together here, largely by welding, and the intertank area, by typical aircraft assembly procedures of drilling and riveting and about a half a mile of welding is our major automated product activity in the 43 acre building which Dr. Siebel was describing to you.

The size and weight in round numbers, it is about 28 feet in diameter, about 155 feet long. It contains propellants, hydrogen at minus 423 degrees Fahrenheit, liquid oxygen at about minus 300 degrees.

On the external portion of that, it has to be guaranteed to stay above the freezing point of water, and therefore insulation added is about half of the labor work that we do here.

We buy half of the tank. We add the other half of value here with labor at this facility, and approximately half of that added labor for the insulation work that we do.

You can tell by the figures there that the hydrogen tank is about three times as large as the oxygen tank. The oxygen tank contains about six times as much oxygen by weight as there is hydrogen, a complete reversal.

The hydrogen is such a light density liquid (about four pounds a cubic foot) but the tank is about three times as large as the oxygen tank.

The status of the articles (Figure 2): we have five at the bottom of the Indian Ocean. All five of those performed superbly on their flights. We have three at the Kennedy Space Center to be joined by a fourth this coming week.

We will ship the third lightweight tank on Tuesday of this

coming week. At that time, we will have four tanks at the Kennedy Space Center. That leaves about eight more in various stages of assembly here at the Michoud Assembly Facility.

The status that you have up there is of 15 February. As of this morning the lightweight tank has moved to the final assembly area where it is being readied for delivery to the Kennedy Space Center.

Lightweight tank 16 is an item of interest. We will start production here at about the middle of this year. Lightweight tank 16 is the one currently designated to go to Vandenberg Air Force Base for the first launch from there.

It delivers from here late '84 to support a late '85 launch at Vandenberg.

MR. WEEKS:

Mr. Chairman, since the lightweight tank is about 10,000 pounds lighter than the heavyweight, and we needed that performance for use with Flight Six - you can see we put one out of order - and we will fly it on Seven. We just switched the order of Six and Seven.

MR. TIMMONS:

Yes, Mike. The lightweight tank was a requirement to increase the performance of the Orbiter and we were by contract directed to reduce the weight of the tank by 6,000 pounds. On the first view graph (Figure 1), you saw that there was about a 2 ton lagniappe of additional weight reduction, and as Mike says, it is about 10,000 pounds lighter than the first tank that was flown.

MR. WEEKS:

An outstanding job done by this corporation, an outstanding job.

MR. TIMMONS:

Thank you for those kind words, Mr. Weeks.

MR. TIMMONS:

We are equally proud of the work that has gone on here in the small disadvantaged minority business contracting (Figure 3). It is kind of a tribute to Jimmy Hughes predecessor, Mr. Greenwood, who was killed in the July crash of Pan Am here last year. Jimmy Hughes has carried that along extremely well.

In 1982, we got the top award of the Defense Logistics Agency for small disadvantaged contracting and probably even more important from the association of those business people who represent small disadvantaged business. We got their award for the year 1982.

As you can see from the data that we do a lot of contracting with small businesses, and that is easier than contracting with small disadvantaged, but we put a lot of effort into increasing the small disadvantaged business work, and I think we have been quite successful as indicated by those two awards that were received here in 1982.

The desire to keep costs down and because we worry about cost growth, the program always tracks the cost growth history from the inception of the tank.

Looking up at the upper left part of that view graph (Figure 4), you will see that those figures up there are in 1975 dollars. If you look at the 1982 column, the external tank listed there is 7.21 million. That 7.21 million relates directly to this figure which is in 1981 dollars. The same tank is that tank in 1975 dollars, priced

for the escalation, it has gone then to mid-point average tank 13.89 million dollars in 1981 dollars.

You can see that there are four quadrants that represent the original and the growth areas of the external tank, the added scope, that is accommodating additional program requirements that we have to meet.

The added scope amounted to about one-fourth of the total growth. The inflation factors which were estimated to be 5 percent at the start of the program as that quadrant is made up, are those inflation figures which exceeded the anticipated 5 percent at the start of the program, and they represent about one-fourth of the total cost of the tank.

Mission model changes or programmatic changes represent also about a fourth of it. These are things like the schedule slide, midpoint of effort to prove out the reduced production rate. The production rate anticipated was cut just about in half, and then the wedge up there labelled experience represents our inability accurately to estimate the complexity of applying the thermal protection system, principally, and it is cost growth beyond the estimate that we thought we could make at the outset of the program.

In order to make the required rate - we are on contract and on schedule to produce 24 tanks per year by the last part of 1987 - requires C of F projects (Construction of Facilities - Figure 5).

The first item (at the top of the Figure) is the facility construction: reprogramming of the 1982 dollars was required to build an ablator facility here on the site. Site preparation is essentially complete for that building and we are in the contract

phase now of estimates and bids to do the construction of the building, that will do several things. It will have the ability to produce lower cost super light ablator components for the External Tank, it will get the silicones out of the factory and will eliminate the contamination they can cause in the circulation of air within the factory.

The approved C of F projects are listed there and the explanation on the facing page shows that they are all associated with meeting the required delivery rates.

For fiscal year '84, the approval at the Congressional cycle is underway right now. Those are the four principal items identified for fiscal year '84 for C Of F.

At the beginning of this year, we have made a significant change in the operation of the facility here (Figure 6). It was a Government owned contractor-utilized facility. As of January of this year, we took over the operation of the facility and it became a true GOCO, or Government owned contractor operated facility.

In the process of taking it over, two contractors here who previously had been contracted under NASA, we took over the work of the facility operating contract and the plant protection work, and put those under what we call Martin badges or Martin Marietta employees. The others, we retained the same contractor or re-competed in order to get an equivalent contractor on board.

The one item of interest at the bottom of the page, Red janitorial work, was recompeted and a company called AME won that contract. They have an extremely interesting method of operation: it is largely a minority group of employees and they will accept and

utilize employees on a four hour day, which turned out to be an excellent proposal to us. We felt that it permitted a person responsible to be the family head to work four hours, during the school hours, and get back home to avoid having latch-key children. We liked their proposal - it was low in cost and they are doing the work we anticipated they would do in an excellent fashion.

We are now operating the facility. We are responsible for everything that involves our ability to produce external tanks now, and on an incentive contract, we feel that's the way it should be, and the program office definitely was in agreement with that. We have now finished, as of February 15, taking over the entire operation of this facility, including paying the electric bill and keeping the roads, grounds, streets, everything clean and maintained.

REPRESENTATIVE LUJAN:

Who is Global associated with? Is it a subsidiary of some other big company?

MR. TIMMONS:

Global is a very large company. It is not the van service. It is an overseas based maintenance kind of a company. They operate in the Arabian countries. I believe they have some contracts to maintain aircraft and aircraft sites for the Government also.

DR. SIEBEL:

Essentially it is not a corporation. It is a joint venture between the Atlas Corporation, which is a public corporation, and a private company called Alconstructors, and they do as Mr. Timmons said maintenance. They run Kwajalein.

MARSHALL SPACE FLIGHT CENTER SHUTTLE PROJECTS	MICHOUD ASSEMBLY FACILITY	NO. _____ DATE 2/26/83 SPEAKER M. P. Siebel

HISTORY OF UTILIZATION

1942 - 1945 Acquired by U. S. Government for Ship and later for Aircraft Production

1951 - 1953 Army Tank Engine Production

1961 - Present NASA Launch Vehicle Production for Apollo, Skylab, Apollo/Soyuz & Space Shuttle

	Program	Prime Contractor	Milestones	
1961 - 1975	S-I/S-IB	Chrysler	First S-I First S-IB	4/1964 3/1965
1962 - 1974	S-IC	Boeing	First S-IC	12/1967
1973 - Present	External Tank	Martin-Marietta	First ET	6/1979

1969 First Tenant U. S. Navy/Bell Aerospace Co.

FIGURE 3

NASA-MSFC-MAP SP-PC-003 (OT) (OCT 77)

MARSHALL SPACE FLIGHT CENTER SHUTTLE PROJECTS	MICHOUD ASSEMBLY FACILITY	NO. _____ DATE 2/26/83 SPEAKER M. P. Siebel

DESCRIPTION

Land: 833 Acres

Total Buildings Area:	34 Buildings	3,768,000 sq. ft. (86.5 acres)
A. Office Area:		902,434 sq. ft. (20.7 acres)
B. Manufacturing & Special Tests Area:		2,467,980 sq. ft. (56.7 acres)
C. Institutional Support Area:		397,598 sq. ft. (9.1 acres)

- Computer Support - Remote Terminals from NASA-Slidell Computer Complex
- Waterway Access

FIGURE 4

NASA-MSFC-MAF SP-PC 003 (OT) (OCT 77)

MARSHALL SPACE FLIGHT CENTER SHUTTLE PROJECTS	MICHOUD ASSEMBLY FACILITY	NO. _____ DATE 2/26/83 SPEAKER M. P. Siebel

PERSONNEL STRENGTH
2/15/83

ET PROGRAM				
MARTIN MARIETTA AEROSPACE	(ET PROGRAM)	4,017		
MARTIN MARIETTA AEROSPACE	(OTHER)	98		
Subcontractors		428	Subtotal	4,543
NASA		33		
DCASPRO		100		
DCAA		8	Subtotal	141
TENANT AGENCIES				
U. S. DEPARTMENT OF AGRICULTURE		1,105		
NAVAL BIODYNAMICS LABORATORY		86		
DCAS (OTHER)		19		
DCAA		23		
CHRYSLER CORP., DATAMAN		13		
CITY OF NEW ORLEANS/AMID		2		
DEPT. OF COMMERCE/NAT'L MARINE FISHERIES SERVICE		3	Subtotal	1,251
			Total	5,935

FIGURE 5

NASA-MSFC-MAF SP-PC-003 (OT) (OCT 77)

MR. TIMMONS:

All right, the principal facility items that we will be bringing on line to accommodate the rate of growth needed to get the 24 per year, are indicated here (Figure 7) as a new cell or nonmajor tool comes on line, that increases our rate capability and then as we learn to use that, you can see a slight increase in rate due to the learning curve on the facility.

It is just to indicate the planning that goes into making sure that we are looking far enough ahead to accommodate today the beginning of facilities that have to be on line to make the 24 tanks per year in late 1987.

And we have a subsidiary plan which enables us to go to 40 per year or more as required by the NASA mission model.

REPRESENTATIVE LUJAN:

Do you do all hand welding or robot?

MR. TIMMONS:

The welding is all automated. It is computer controlled operator verniered. The last thing that happens is that an operator watches the pool or the puddle and makes minor adjustments. It is generally a rotating part or a moving head, automatically programmed to move, the rate at which it moves, the feed, the speed, the current, all of them are controlled by computer with very minor adjustments.

You wouldn't call it robot as much as automated welding. It is fully automated. As I said before, it is about a half a mile of welding and most of it is three pass welding where you have the seal, fusion and filler pass so it is about a mile and a half of

welding, and all of that, no exceptions, all of that is automatically controlled welding. We call it robot welding.

In the control of the cost growth and in the requirements to get the cost down (Figure 8), we made a commitment to NASA over two years ago that we would reduce by 66 million the cost of the first 60 tanks or the cost of the first 54 production articles.

Over the first year, we fell just slightly short of achieving the goal. The second year we picked that up, and exceeded the goal. The third year we have gone into the 1983 requirements and I believe there are only about 6 million dollars remaining in that goal to achieve the 1983 cost reduction requirements that we had committed to in the first place.

So we are at about 60 million of total cost reductions on those tanks and that's on those tanks only, and the run out benefits will, of course, far exceed that 66 million dollar figure.

So as the program goes on, the savings will be amplified and multiplied by the total quantity of tanks produced.

CHAIRMAN VOLKMER:

How much would you allocate that on a per tank or would you be able to say?

MR. TIMMONS:

Yes, it is about nine hundred thousand per tank, isn't it, Ric?

MR. DAVIS:

Actually, since we implement them at various effectivities, the later tanks get much higher than the earlier ones. Effectivity started at lightweight one and now are all the way up to about lightweight 23, so the earlier ones would be small. The ones out

like lightweight 54 would probably be around a million and a half.

REPRESENTATIVE LUJAN:

What about the ones you are working on now?

MR. DAVIS:

I would be guessing to give you a number. I can get you a more specific number.

REPRESENTATIVE LUJAN:

Somewhere between a million and a half and nine hundred?

MR. DAVIS:

Somewhere between a half a million and a million and a half, and I would have to look at the numbers to tell you about the ones we are working on right today.

MR. TIMMONS:

Not all the tanks that have been produced have all of these cost savings associated with them.

For example, a major cost savings there is to replace the superlight ablator and the spray on foam insulation with a newly developed North Carolina Foam Institute foam. That will be a significant savings. That first goes on lightweight tank number Four; it is in the process right now of being put on. The savings sequence through the production run and the work, such as the foam spray and the new work that we are doing on welding, all of this is jointly done with the Marshall Space Flight Center. With their laboratories and their competent technical people, we are able to do development work in parallel with what we are doing here. The work at Marshall is all planned and estimated in the funding that we get for doing the job here. The set-aside for the work that is being

done at Marshall is taken out of the value of the contract here.

MR. ODOM:

Mr. Chairman, what we do is we have programs where we start a development program within our laboratories, and I believe you will see this from your tour on Monday, and then we bring the benefitting contractor in to work that development directly with our people, essentially then we make the information transfer an automatic thing and as soon as the development is over, the contractor has people who have been in the development trained, and they have their technicians already involved so that they can take it immediately and institute it into the manufacturing or production program.

That has worked very well for us, and I might say the two areas that are quite significant to the tank in this area is the new foam which Mr. Timmons referred to, and also plasma welding, which we will be doing shortly, and it looks very promising.

It is probably one of the bigger break-throughs in aluminum weldirg in the last 20 years. You will see some of that already going into production here on your tour today, and you will probably see that equipment in process on Mondays tour.

It is something that is paying off, we think, extremely good dividends, utilizing both our people as well as our contract people.

MR. WEEKS:

I think we should clarify, Mr. Timmons, that 450 million there at the bottom of your chart is in the ballpark of about 2 million average through the mission model and both as Mr. Odom said and Martin Corporation are slogging in the trenches there with those 80, and then 73 and that is the way you did it on the F4 at McDonnell.

Getting cost out is a back breaking tough job that you can't write memos in Washington about. You have to do it by this change or this improvement, go through the hours before and the hours after, decide you are willing to do it, for all the reasons of safety, et cetera, and then go do it.

And it is a back breaking job, but there is no other way. Headquarters can't write a mighty memo that does anything. I mean its a lot of dedicated people at Marshall and Martin that actually make that happen.

That is how it is done. They are doing the best job across the whole program of this slogging in the trenches. They really are making a steady week by week, month by month progress. That's the way it is done.

MR. TIMMONS:

You can see from the facing page (Figure 8) of that cost reduction is a formal program divided into about 3 distinct ways of achieving cost reduction. One implies those little changes that can be made without a drawing change. Another area, we have to file back through the system for a drawing change in order to implement new engineering designs which can reduce the cost.

And of course, we have contributions from motivation and suggestion programs, other things that have continued to bring the cost down. The total savings through the mission model is, of course, dependent upon the size of the mission model, as Mike says.

Without Mr. Winn here, this isn't as interesting a view graph (Figure 9) as I often found it when he was here with the subcommittee.

Going back to 1977, this is a figure that alerted, alarmed, frightened everyone. That is the turnover figure from the hourly employees in one year of 1977.

It was that figure and the recognition that in this area that isn't an unusually high figure for manufacturing labor turnover, but that caused us to set a goal for a stable, well trained work force here, which we needed, we had to have, to get Mission Success and to get a high quality product.

We took steps which have been extremely successful in bringing the turnover down. You will see that there was a reversal in the year 1981. That was the year of our maximum hiring effort, and that was things like Mr. Heiter identifying a new hire as not being able to make it, and over half of the people that left in that year were involuntary or fired, in other words, for inability properly to do the job.

But over the years, the trend is down. We are doing extremely well. We are not only well below the area turnover rates, we are now below the national average of turnover published by the Aircraft Industry Association for like firms in the United States today.

REPRESENTATIVE LUJAN:

13.7 percent is lower than the national average turnover rate?

MR. TIMMONS:

Yes, in the Aircraft Industry Association figures, you will find that it runs about one and a half percent per month, which is a fairly average figure of all of their figures that they publish, about one and a half percent per month.

REPRESENTATIVE FUQUA:

Tell him what the figure is in the New Orleans area?

MR. TIMMONS:

In the New Orleans area the figures got down to 35 percent two years ago, and went back up over 50 percent, over half of the people in the manufacturing labor in the work force changed jobs each year.

REPRESENTATIVE LUJAN:

That's surprising because, you know, with the conditions you would think nobody would quit their job nowadays.

MR. TIMMONS:

Well, you might see some of that reflected in our last year out here where the improvements are extremely good.

CHAIRMAN VOLKMER:

Some of that is probably involuntary, though, too?

MR. TIMMONS:

In the exempt salary, that is a new low for our work in the exempt salary area here. I think that reflects no one leaving because there is no place to go.

CHAIRMAN VOLKMER:

What is exempt salary and nonexempt salary?

MR. TIMMONS:

Those are the Fair Labor Standards Act of 1938 references, exempt salary means you are exempt from the Wage and Hour Laws. Nonexempt is, let's say, clerical support or a person who might run a word processing machine and then hourly, of course, are the production employees and they are represented by a union here. Not all of the hourly employees who are represented by the union are members of the union.

REPRESENTATIVE LUJAN:

You have open shop in Louisiana?

MR. TIMMONS:

Yes, sir, and this is not yet considered a federal enclave. It is an open shop; State law controls it.

Anyway, it has been very fruitful and very productive to do those things which help the work force, motivate them, and keep them here.

One thing that as I say, in '78, we set out to accomplish that stable well trained work force, and in 1978 we set up the System Refinement Team (Figure 10), which is another name for Quality Circles. These are quality circle data that we have compiled. We do not target cost reductions for quality circle workers. We merely invite them to do those things that make their own work better, their work place better, to help in the quality of their work life, and then to determine is it working: is it doing as good, and now we have 54 teams now in work. We have 27 teams being formed at subcontractors, and I believe we will be working with the NASA centers on helping to form some other teams within NASA.

We have some management teams and some combined teams with DCAS, with the NASA people and with our people, in things like weld improvement, MARS reduction, MARS is an Anomaly Reporting System. It has been very fruitful. In order to measure it, we did look at those things that you can measure on employees, such as unpaid lost time, that's time away from work, grievances, safety accident, safety incidents, and attitude related attrition, and all of those for hourly SRT members are better than for hourly people not participating.

There is one figure that has suddenly gone very low here. We incorporated into the Quality Circle teams, the forklift operators. They volunteered. They wanted to form a team. They did. They brought into the quality circle groups the highest incident rate of damaging hardware, because they are the people who have the greatest opportunity to damage hardware.

So that brought that figure a little lower. It was running around 40 percent up until the time that they incorporated that team, but then to make sure that we just weren't looking at figures for people who had joined the quality circle because they were good people, we developed the statistics for the people before they joined the team and after they joined the team, and the figures there are, I think, even more dramatic, showing tremendous reductions in things like attitude related attrition, safety incidents, accidents grievances, unpaid lost time all show that it isn't the better people who are joining the teams.

It is the teams that are making the people better.

REPRESENTATIVE LUJAN:

Is the team for the operators of the forklift and those sort of things, how to improve that segment of the plant?

MR. TIMMONS:

It is in their own work area, yes. They are free to make suggestions in almost all areas. However, their concentration is in their own area.

For example, the forklift drivers felt that they were being forced to have accidents by careless pedestrians, and so they came up with the suggestion that we should enforce more strongly the

rules of people staying in the aisles, walking carefully and they are developing their own posters now to be put throughout the shop in order to encourage pedestrian safety.

So the forklift drivers don't have to veer and damage some of the load that they are carrying. That is the kind of thing they will do.

They will also come up as circle members with large cost savings suggestions, but as I say, we do not measure that as a figure of merit, because we want them to improve their own work place. We want them to be participative in management, and I believe it has paid off tremendously in helping to get the attrition rate down to that very low level that we now have.

In order to accommodate the higher rate of production, we have started a very ambitious program for the Integrated Parts Status System (Figure 11) and that is about two-thirds working here today.

By the end of the year we will have the last five modules on board and functioning for that. What it represents is the ability automatically to control everything from the drawing release through the scheduling of the shop, through the documentation of the hours of labor applied in the shop, through the purchasing loop, even all the way through to accounts payable - essential that that be done in an automated fashion at the rate of production we are heading toward, as I say, it was an ambitious program to try to integrate all of those modules that have been put together throughout the country. Many of them came from discretionary funding expenditure. For example, three of the programs (three of the modules) came out of Denver from previously developed programs under discretionary

funding. One came from Orlando and the final one there, the MIMS was developed here totally under the contract, and that is the overall integrating program that makes all the modules that are listed there work together.

It is called the IPSS. It interfaces also across lines with other operating programs that we have here, such as the finance program, and the planning program, but those two are not in the Integrated Parts Status system.

Eleven modules are in work and functioning. Five more will be released by the end of '83. That system should be fully functioning and controlling our entire destiny here at this Michoud Assembly Facility.

Another item (Figure 12) that is coming on now and, at first glance it might look like it is a little late to be coming up with, is computer-aided design. The principle function here is computer aided manufacture. It is to take those data which help control the configuration, the design, have those available and displayable, and even rotatable and three dimensions to be made available for the liason call solutions for the disposition of anomaly reports, to streamline the system so that manufcturing can get immediate positive, fast service from engineering or from those parts of the organization that do control the disposition of an anomaly report. For example. The operators are in training now. The machinery is here. We will have it on the floor by the end of this year, and it should streamline and accelerate tremendously our ability to process tanks through the shops, and in particular to disposition anomalies that occur, and reschedule tanks depending upon those anomalies.

REPRESENTATIVE LUJAN:

I would like to ask a question along those lines. It has nothing really to do with the programs that you have in there, but it seems like everything is run by computers these days, then and if you don't understand that thing you are dead. Do all of the managers of the various divisions within the whole center, do they get some training to understand this whole thing or is the computer part left to somebody else to do, or is each one of the heads of the departments intimately familiar with what they are doing over at the computer, the whole system that is computerized?

MR. TIMMONS:

For those who aren't, we did recommend that they hire an assistant who understands the computer system completely so that they could get proper advice on what should be in the machines and what isn't. No, they don't all understand that all intimately.

We have a separate group that does the programming and the software work for the computers, but we do it in a variety of ways.

An interesting example, the contracts for Tom Wirth, our man at Kennedy Space Center, who does the receipt, check out, nd preparation for launch of the tanks there, approached it in a totally different way from having a software group. He took his young engineers who knew the system, who knew the hardware, the valves, the pumps, and those people learned the GOAL language which NASA made available and it was a good step in having GOAL which is an easily understood software system.

Those engineers then developed their software instead of putting it into a group for software development. It works both ways. That

worked extremely well. On the automated loading, for example, loading hydrogen and oxygen at the Kennedy Space Center.

Here we established requirements within the various functional groups. The requirements are given to our computer people to be put into software and into the program as far as the things like the Integrated Parts Status system.

Now, Bob, do you want to add anything to that?

MR. SMITH:

Well, the departments do write detailed specification requirements. We call them user requirement documents for the modules, for their individual systems, and these are written in their language, and they work directly with the systems analysts who are the computer side of the house, and a systems analysts with them then write a thing we call the functional system design, and it is the first step in the computer training.

So at that point, the two of them are really talking a common language as they bridge the gap between the user terminology for what he wants to do with that data system, and the designer of that data system. That is brought to the programmer to finally to turn into a product.

MR. DAVIS:

I would like to pick that up and make one comment, too. We have a formal training program here for all of our skills and we have a very good training department, and that training department has a piece in computer operations. While we may generate user documents and generate systems, we also train the people how to use that system, so it starts with the user and ends up by training them to

use the final thing that he asks for.

MR. ODOM:

I would like to take it just a step further, because it is a very valid question, because most of us that have been in the business for a long time. We know what needs to be managed, but we are not that current on what programs, what machines are really available in today's market.

We are learning a lot of the same things that you have heard Ken say. We are bringing younger people into our organization that are familiar with the machines and with the programs that are available today, and we are using them to a large degree to help us really understand what is available, and integrate that into our management system.

The bottom line for your question is that you will see in my office, and in most of the managers' offices, a terminal within the next few months. We will then have the data available to us from our contractors and from within the Center (both management data and production data) that's available without generating paper and passing it back and forth.

We have to get out of that mode. That business is moving so fast, it is very difficult to stop a program long enough to join it, but we are trying very hard across NASA to do just exactly that, and we have made significant strides in the last two or three years, and it will be not only be valuable, it will be a mandatory tool that we use to minimize labor and to minimize paper, and it looks extremely promising to be able for us to do that.

MR. COLDWATER:

Jim I would like to add to that, also on the engineering side of the house. For instance at Marshall, I know that the laboratories will have a similar situation as what you are talking about, so that they will have not only access to the program and production data, but also be able to tie into the contractor for analytical work or verifications.

REPRESENTATIVE LUJAN:

I didn't mean to get us off of the track, but I just think that's kind of interesting.

MR. TIMMONS:

That is a good question. There is, I think, a dangerous trend for computer systems to proliferate. The establishment of a requirement doesn't automatically cause a computer system to be developed for that particular operating department - it has to be proved that it is needed and it is cost effective, and it will do a specific function, and it needs constant control, because everything will be in the machine before we get through on this CAD/CAM system, where we have off site locations, like Jim Odoms' office will be on that line in the plant, plus all of our Los Angeles offices. People who procure many of the major supplier items for the tanks are from the Los Angeles area.

CHAIRMAN VOLKMER:

Now, as each tank goes through the line, will it be followed on the computer operations?

MR. TIMMONS:

Yes, that's right, it will be. We will have a back-up system so

that if lightning strikes or something takes out the primary computer, we have to have a backup. Otherwise, we would have to walk out on the shop floor, blow a whistle and say, don't do anything until the computer comes back on line, because we won't know what's where and what is being built. It will be a backup fool proof system and it will be on line this year. It will cover all things.

The summary here, I don't know whether to have Mike read it or whether I should do it, but the five flights have been extremely successful. As I said before, we will have by the end of next week four tanks at the Kennedy Space Center, and I believe that represents about the years supply of tanks needed for the flights coming up this year at Kennedy.

The awards that we have received for the small and disadvantaged business work, we are very proud of. The production rate of 24 per year, we are confident, can be achieved as required in late 1987.

And future growth can be accommodated as required, should NASA and the Agency elect to go on to 40 or more tanks per year.

The computer systems, we have just covered a good deal. Productivity has been fruitfully pursued, and I am extremely proud also of the programs of producibility, production readiness and the quality of work life programs.

That and bringing the cost of the tank down, and helping also to establish that stable, well trained work force that is so badly needed.

We continue to coordinate very fully with the program office at Huntsville and the funding requirements are jointly agreed to and have been met with precision over the years.

And Mission Success is our most important product we are totally committed to that.

That concludes my presentation. I will be happy to answer questions, of course.

REPRESENTATIVE FUQUA:

Just so I can get myself a little more familiar before I go out and look at the plant, on the tank production, it is a little hard for me to understand. Do you manufcture a tank within a certain area of the plant, or do you have lines of production?

MR. TIMMONS:

The parts flow through the shop. The lines of production are represented mostly by the final assembly areas where you will see the ability to have three in a row. But in general, it is a sequence of parts moving through the facility.

REPRESENTATIVE LUJAN:

Through an assembly point?

MR. TIMMONS:

To an assembly point, to a test building, to the Kennedy Space Center. The assembly also includes, of course, the thermal protection system application and you will see those cells in the high bay areas today. Those have been brought on line plus all tanks flowing through there also get the thermal protection system applied to them.

CHAIRMAN VOLKMER:

Do you have plenty of room for additional assembly points?

MR. TIMMONS:

Yes, we have facility layouts which show that we can accommodate

the 40 per year, with a limited number of new facilities, by the rearrangement of some tools on the floor but yes, we have adequate space.

REPRESENTATIVE LUJAN:

You see no problem in the future with subcontractors producing parts on time?

MR. TIMMONS:

No, the subcontractors have all been working with and are committed to support the 24 a year and the lead time is such that they are almost there in some cases, in the ability to produce 24 a year, it takes approximately 15 months for a tank to go through this facility. They are started much earlier than that at the subcontractors who fabricate things like the gore sections, stretch forming or hydroforming. Those are well ahead of our production rate here at this time.

Jimmy Hughes and his people have worked on the production readiness plan with those suppliers and guarantee that we don't have a sole source supplier who cannot make the rate.

CHAIRMAN VOLKMER:

Okay, what would be the total cost of the tooling to get where you were at the end of the development stage into lightweight to the capability to have 24 per year. Do you have any idea of the total cost of tooling up?

MR. TIMMONS:

To get from where to where?

CHAIRMAN VOLKMER:

Where you were at the end of the development stage to what I call the first lightweight.

MR. TIMMONS:

Mr. Davis?

MR. DAVIS:

Our latest POP projection to get 24 per year was about 306 million. That includes everything in tooling. Now, some of those classes of tools some people may not consider tooling. What I mean by that is it does include things like inventory management. Such as the shelves, the racks, the things we need to store and then move the parts out to the production line. It does include everything we need to activate this facility to produce 24 per year.

CHAIRMAN VOLKMER:

That's all types of equipment?

MR. DAVIS:

Right. All types of equipment. Everything. Not just the tools we use to actually put the parts together. Everything that it takes.

CHAIRMAN VOLKMER:

Now, from what I have seen in your turnover rate, I think I probably know the answer, but what would you estimate the present employee morale to be. That is a leading question. Ken, you can say anything you want.

MR. TIMMONS:

I think it is outstanding. The morale of the employees on the floor as represented by their demeanor, appearance, their response to us, I think is excellent.

CHAIRMAN VOLKMER:

And, of course, everybody I suppose even the hourly people, know that you are eventually going to get to 24?

MR. TIMMONS:

You bet they do, and they also know that there is stability here, and it is an awfully good item to improve their morale. We keep emphasizing that we will probably be producing tanks here through the rest of the century.

CHAIRMAN VOLKMER:

When we get to 24 a year, how many hourly employees will you have? Do you have any idea?

MR. TIMMONS:

About 2500.

REPRESENTATIVE LUJAN:

That's what you have now, isn't it?

MR. TIMMONS:

Not quite that many hourly employees.

MR. HIETER:

The hourly employees, I believe, would be around 1500.

REPRESENTATIVE VOLKMER:

And the total number would be 2400? What would your total number of employees be?

MR. TIMMONS:

Thats on the curve that I showed you, it's about 5000 employees. The overall quantity of employees doesn't increase very rapidly from here on it is a shift in the work force toward the larger group of hourly employees.

CHAIRMAN VOLKMER:

Now I noticed one thing when I went through the budget earlier on, I have had some of our staff check it out, so we pretty well now

know the answer. I would like to understand where we go from here to 24 on this end, is that I understand there are some funds in for additional dock facilities.

And that of course all tanks have to be barged out? Right now you are able to what, do two, handle two barges or how many?

MR. TIMMONS:

Yes, currently two barges at the large dock.

CHAIRMAN VOLKMER:

The new facilities will enable you to do four?

MR. TIMMONS:

That is right. We will refurbish one position and that will add a third barge position, and there will be a storage position ultimately, I believe in 1985, for a fourth barge position.

REPRESENTATIVE FUQUA:

That barge facility is not in this book you have, is it?

CHAIRMAN VOLKMER:

That is not in the manufacturing department. That is transportation.

REPRESENTATIVE FUQUA:

I was going to ask what is the facility's budget and how much. You've got them in there as four items but no money.

MR. TIMMONS:

Those four items are comprised of about 12.6 million dollars as the budgetary estimate.

REPRESENTATIVE FUQUA:

When was the proposed dock facility added?

DR. SIEBEL:

What Mr. Timmons presented was what one might call a production related facility and then we have others called "institutional" which amount to an average of about two million dollars a year. We did not show you, although I can if you so desire.

CHAIRMAN VOLKMER:

Four is all you are going to eventually need?

MR. DAVIS:

For 24 per year, right

CHAIRMAN VOLKMER:

For 24 per year rate that is all you need?

MR. DAVIS:

Currently we barge with one barge and one tug, and when we hit rate we will eventually tow in tandem two barges and a single tug. Two tugs will be required to support KSC and VAFB at 24 per year. At that rate we will basically have three loading positions and one storage position. Currently today we have the two loading positions.

CHAIRMAN VOLKMER:

What happens when you send one over to Vandenberg?

MR. DAVIS:

It takes about five days to Vandenberg.

MR. TIMMONS:

That is to Kennedy Space Center.

MR. DAVIS:

I'm sorry, that takes about twenty days each way.

CHAIRMAN VOLKMER:

What happens when you send two tanks off to Vandenberg?

MR. DAVIS:

We have in the four barge position rate capability to also have time for downtime for maintenance on the barges as well as for necessary trips to Vandenberg and the Cape. Four will do the job.

CHAIRMAN VOLKMER:

Spare parts?

MR. DAVIS:

We have a well defined and implemented spare parts program for flight hardware, tooling and facilities.

REPRESENTATIVE LUJAN:

I am just surprised that you don't have to increase your work force. You say you will have about 5000 employees and you have 4500 now.

MR. TIMMONS:

That 4500 includes the employees at Kennedy Space Center. On site here we have about 4200. This location will probably go to about 5000 perhaps as high as 5500 total work force.

REPRESENTATIVE LUJAN:

What do you have here now in this location?

MR. TIMMONS:

4200

MR. DAVIS:

Basically what's happening, is we are increasing the number of touch laborers and the number of engineering and support people is coming down so that the work force doesn't grow through the touch labor the way you think it would, and then as we hit our peak in about two years, then the learning curve starts driving us down, so

that we can sustain 24 per year production rate with a slight decrease in work force.

CHAIRMAN VOLKMER:

In other words, you won't have to have as many people per tank?

MR. DAVIS:

Right.

REPRESENTATIVE FUQUA:

Have you looked at any of the possibilities of flying them out there on the back of a 747?

MR. DAVIS:

I know NASA has been doing some studies on it.

MR. ODOM:

Yes, sir, Congressman Fuqua we did look at that. As a matter of fact, several times. One of the major drawbacks was the size of the tank. Essentially, the tank aerodynamically blanks the tail and you would have to put extensive additional control surfaces as well as control equipment on the 747s to accomplish that.

REPRESENTATIVE LUJAN:

What about the guppy?

MR. ODOM:

It is not big enough to hold it. When you see it, you will understand it. We did look at that. I wouldn't say it couldn't be done, but it is also not only that it also ties up a 747 for a period of time, so we have looked at other alternatives.

REPRESENTATIVE FUQUA:

Once you start landing back at Kennedy, or should there be launches and landings at Vandenberg, you are not going to have the

need for that as much as you have now, where you have to haul it back all of the time.

MR. ODOM:

We looked at many alternatives, the 747 being one of them. The most economical turns out to be if for some reason we lost access to the Panama Canal, which with our trips obviously take into account the most economical, is essentially to take a commercial ship that has a large flat deck, which you can pick the tank up and sit on as a backup which there are a lot of those class ships making that trip around the Cape on a day to day basis.

So from our standpoint the most economical backup was just to go commercial ships as opposed to modifying the planes.

REPRESENTATIVE FUQUA:

That's a better mode of transportation?

MR. ODOM:

That's right, and especially with the low rates. That goes to Vandenberg that turns out to be much more economical. The front end costs for modifying the 747 was pretty expensive.

MR. SMITH:

We also, and this was about 8 years ago, as I recall that we looked at it, and it was quite a problem to get the tank up on and inverted on the 747, with the ground handling equipment, the hard points, and we only have one hard point, flight hard point, and that penalized weight-wise the tank.

You would have to build some other hard points on it?

MR. ODOM:

That's right. You have got to build ground space here that simulates the Orbiter loading device, you know, the big structure

that loads the Orbiter onto the 747. You also have to have it large enough to rotate the tank so that it won't fly bottomside upwards, compared to the way we haul it on the barge.

So by the time you price in the modifications to the 747 and that large piece of ground equipment, then it really would be just more economical to use the ship.

REPRESENTATIVE LUJAN:

And how do you get it to the port? Do you truck it in, either to Vandenberg or Cape Kennedy?

MR. ODOM:

At the Cape, we come right in. We have a dock there, right in the immediate vertical assembly building area, just a few hundred yards from the vertical assembly building. We finish the assembly of it on a large transporter. We then roll on the barge and roll off the barge right onto the roadway into the vertical assembly building, and we do exactly the same thing at Vandenberg. It comes into the dock there on South Vandenberg, from there on the same transporters that we use here for the final assembly.

REPRESENTATIVE LUJAN:

Does the transporter stay with barge?

MR. ODOM:

What we try to do, if we can, is to work it such that the barge comes back. It brings either the transporter or a transporter back with it, so that way it minimizes the amount of transporters that we have in the shipping flow.

CHAIRMAN VOLKMER:

All right, if there are no more questions, we are finished.

(Whereupon, at 11:00 o'clock a.m., the hearing in the above-entitled matter was concluded.)

[Figures 1-12 of Mr. Timmons' oral presentation follow:]

19-605 O—83——56

Subcommittee on
Space Science and Applications
of the
Committee on Science and Technology
U. S. House of Representatives

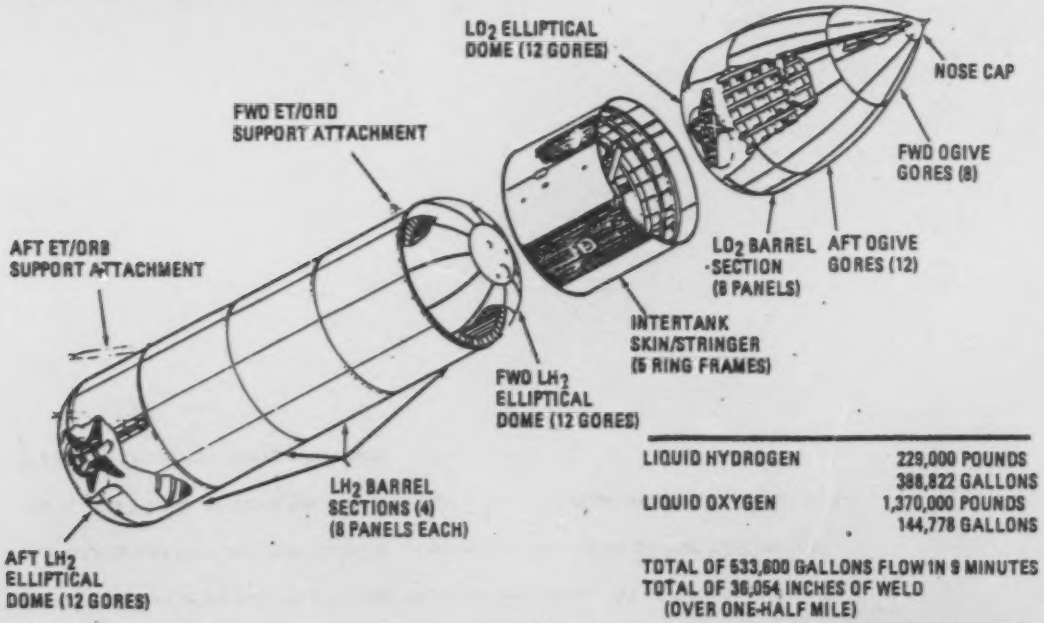
Agenda

9:30	Welcome/Introduction to MAF	Dr. Siebel
	External Tank Production	Timmons
10:45	Tour	Timmons

Approximately fifty-three percent of the flight hardware value was accrued from sub-contractors. During 1982 vendors represented forty-five states and in prior years, depending on the procurement requirements, forty-eight of the United States were represented

Space Shuttle External Tank

LENGTH	153.88 FT	(47 METERS)
DIAMETER	27.58 FT	(8.4 METERS)
LWT-1 SPEC WT	71,278 LB	(32,342 KILOGRAMS)
LWT-1 ACTUAL	66,824 LB	


LO_2 ELLIPTICAL DOME (12 GORES)
NOSE CAP
FWD ET/ORD SUPPORT ATTACHMENT
FWD OGIVE GORES (8)
AFT ET/ORB SUPPORT ATTACHMENT
LO_2 BARREL SECTION (8 PANELS)
AFT OGIVE GORES (12)
INTERTANK SKIN/STRINGER (5 RING FRAMES)
FWD LH_2 ELLIPTICAL DOME (12 GORES)
LH_2 BARREL SECTIONS (4) (8 PANELS EACH)
AFT LH_2 ELLIPTICAL DOME (12 GORES)

LIQUID HYDROGEN	229,000 POUNDS 388,822 GALLONS
LIQUID OXYGEN	1,370,000 POUNDS 144,778 GALLONS

TOTAL OF 533,600 GALLONS FLOW IN 9 MINUTES
TOTAL OF 36,054 INCHES OF WELD
(OVER ONE-HALF MILE)

236.2.63

FIGURE 1

MARTIN MARIETTA
MICHOUD DIVISION

Flight Article Status

Each of the External Tank flights was extremely successful. Three tanks are now at Kennedy Space Center and being readied for launch operations. All of the tanks currently in production at MAF are on or ahead of schedule according to NASA POP 82-2 requirements. LWT-1 was delivered five days early; LWT-2 was delivered two days early and LWT-3 is planned for delivery twenty days early

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Flight Article Status - as of February 15, 1983

ET-1 - Flown

ET-2 - Flown

ET-3 - Flown

ET-4 - Flown

ET-5 - Flown

ET-6 - Erected at KSC in checkout

LWT-1 - Mated at KSC for launch

LWT-2 - In high bay 4 at KSC

LWT-3 - Systems checkout in building 420

LWT-4 - In cell "A" for ET splice

LWT-5 - LO_2 I/T in cell "J" for SOFI, LH_2 in cell "C" for SOFI application

LWT-6 - LO_2 I/T splice complete, LH_2 in cell "N" for ablator application

LWT-7 - LO_2 proof test complete, I/T TPS application, LH_2 in building 451 for proof test

LWT-8-11 - In various stages of sub-assembly and component preparation

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MARTIN MARIETTA
MICHOUD DIVISION

FIGURE 2

239.2.83

Small & Minority Business Status as of 12/31/82

	Total Applicable	Awarded	Percent
• Small Business			
Procurements	182,624	137,199	75.1%
Value	$559,002,218	$254,942,811	45.6%
• Small disadvantaged business			
Value of opportunities to bid		$ 20,126,323	
Number of awards		3,045	
Value of awards		$ 8,724,236	

SBA/DCAS RATING "EXCELLENT"

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FIGURE 3

MARTIN MARIETTA
MICHOUD DIVISION

239.2.83

Cost Per Flight History

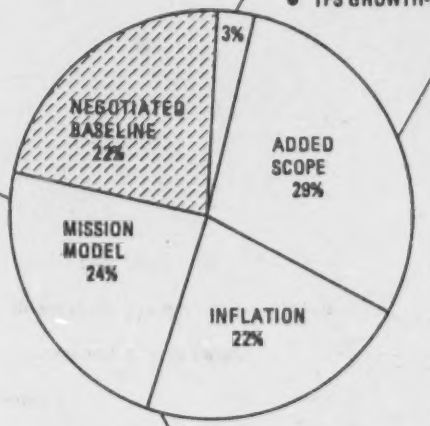
Since the basic proposal negotiations in late 1974, the average projected cost per ET has increased because of:

- Added work scope from requirements changes
- Development experience
- Shifting (delays) in production mission model
- Reduction in total quantity of ETs and rate production
- Inflation above previously negotiated rates

Cost Per Flight History

COST PER FLIGHT 75$	1976	1980	1982
FLIGHTS (TANKS)	572	487	234
ET-MMC ($M)	2.55	4.15	7.21
% OF STS	15.9	15.8	12.4

1981 $
ET-MMC 13.89



MISSION MODEL

- SCHEDULE SLIDE (4½ YEAR MIDPOINT SHIFT)
- REDUCED MISSION MODEL
- REDUCED PRODUCTION RATE (60/YEAR TO 24/YEAR)

EXPERIENCE

- TPS GROWTH-HIGHLY DEVELOPMENTAL

ADDED SCOPE

ORBITER

- ICE DEBRIS
- ICE ON PROTUBERANCES
- LWT
- LO_2 ECO SENSORS

ENVIRONMENTAL

- 1974 FLIGHT LOADS
- AERO HEATING REQUIREMENTS
- PROTUBERANCE AIRLOADS

OTHER

- I/T MATERIAL SUBSTITUTION
- RANGE SAFETY
- FACILITIES TOOL MAINTENANCE

INFLATION

CONTRACT NEGOTIATED AT 5% ESCALATION
HOWEVER, 8 OF PAST 11 YEARS EXPERIENCED DOUBLE DIGIT INFLATION

(POP 82-2)

FIGURE 4

MARTIN MARIETTA
MICHOUD DIVISION

Construction of Facilities

Requests for a number of modifications and new construction facilities have been submitted to MSFC to support increasing External Tank production at the Michoud Assembly Facility.

Congress has approved the reprogramming of the following FY-82 C of F project:

Item	Description
1	Net molding will be utilized to apply ablator material (SLA) to ET components

Congress has approved the following FY-83 C of F projects:

Item	Description
1	Provides controlled climates for priming, BX-250 application and stacking
2	Adds a second crane with 180' span and 172.5' clear height
3	Increases crane capacities, connecting previously segregated crane systems
4	Controls climates for each horizontal position of the tank by installing six partitions
5	Provides a wide main aisle for moving tanks, relocates x-ray facility, realigns cranes

FY-84 C of F projects submitted to NASA headquarters:

Item	Description
1	Provides north/south, east/west feeder aisles, LH_2 barrel and dome installation, in process staging and ogive area
2	Provides LO_2 and LH_2 post proof x-ray, two ET mod and rework positions and staging for ETs and components
3	Provides expanded area for increased SOFI component production
4	Provides a new 500,000 gallon demineralized water storage tank

Construction of Facilities

- Congress approved FY-82 reprogramming

Item	Title	
1	Component ablator facility	15.0

- Congress approved FY-83 C of F project

Item	Title	
1	High bay addition Phase II Cells "K" & "L" (114)	6.7
2	New cranes, Phase II VAB (110)	4.2
3	LH_2 tank bridge & hoist modifications (103)	1.3
4	Environmental control, horizontal installation positions 1, 2, 3 & 4 (103)	2.8
5	Modifications for production flow	2.8
	Total	M$ 17.8

Martin Marietta FY-84 C of F project submittals

Item	Title
1	Modification to production flow, Phase II
2	X-ray modification and staging facility
3	SOFI component facility modifications
4	Tank farm Phase II

NOTE: FORWARDED TO NASA HEADQUARTERS BY MSFC

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FIGURE 5

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MICHOUD DIVISION

Facility Operations

- ET project benefits
  - Places total responsibility for management and control of facility operations with ET contractor
  - Contributes to achievement of low cost production program and simplifies and improves NASA's span of control
  - Consistant with incentive pricing and eventual fixed price contractural arrangement
  - Sub-contractor continuity is maintained

Facility Operations

Operations/ Services	Previous	New Sub-Contractor	Martin Badge
NASA-MAF facility operating contract	Global Associates		√
Roads, grounds and refuse	Hollins & Hollins	Hollins & Hollins	
Cafeteria services	Morrisons	Morrisons	
Vending machine services	Canteen Corp Inc	Canteen Corp Inc	
Plant protection	Reguard		√
Printing, reproduction and photography	Robinson Printing	Robinson Printing	
Janitorial	Red Services	Red Services & AME	

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FIGURE 6

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MICHOUD DIVISION

MAF Production Capacity

There are five major tooling/facility projects (cells) which will step up the production rate to 24 tanks per year by 1987

They are:

1. Cell H - On line June, 1983 for LO_2/I/T SOFI
2. Cell J - On line April, 1984 for LO_2/intertank splice and SLA bond
3. 5019 - On line July, 1985 for LH_2 major weld
4. Cell K - On line August, 1985 for LO_2/prime and dome SOFI
5. Cell B - On line June, 1986 for LH_2, forward dome and barrel SOFI

MAF Production Capacity

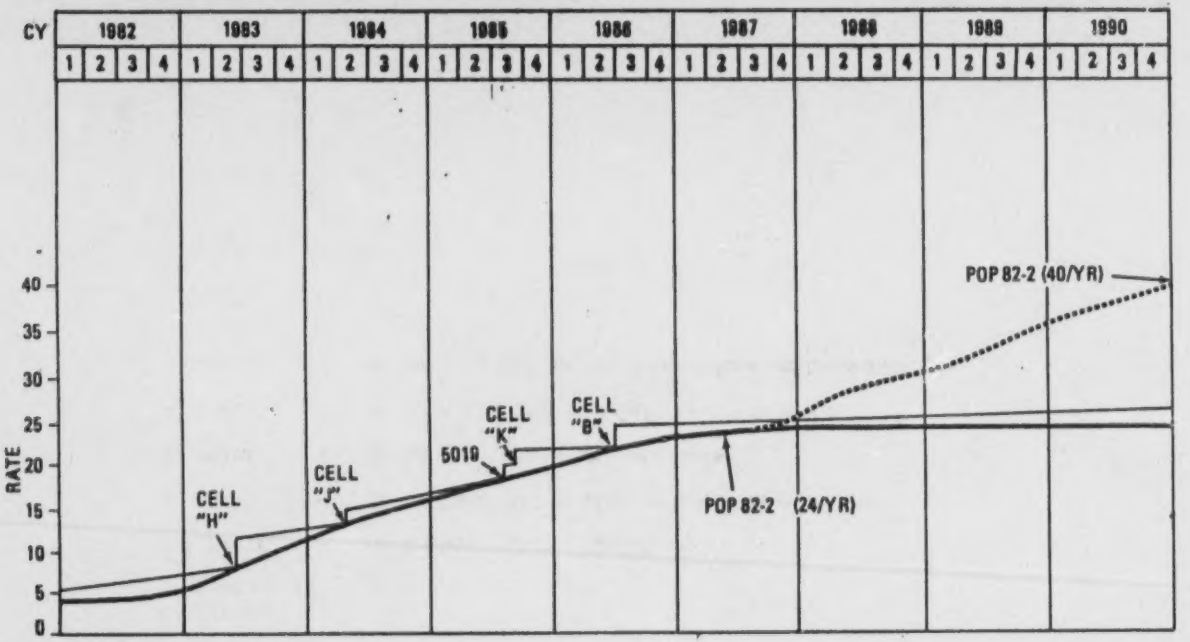

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FIGURE 7

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MICHOUD DIVISION

Cost Reduction-Productivity Program

The cost reduction approach is focused on distinct areas:

1. Producibility Assessment Program (PAP)

   Cost reduction candidates are screened, assessed, recommended for development or implementation (implementation with MSFC approval only)

2. Production Readiness Program (PRP)

   Action is taken primarily to achieve rate and improve productivity to reduce cost

3. Producibility Engineering Program (PEP)

   Drawings are reviewed for alternative designs to reduce costs and speed production

4. Joint effort with laboratories at MSFC have developed and introduced advanced welding and TPS insulation technology with resulting cost reductions

5. ET production continues to be within budget and as scheduled

Producibility/Productivity - Results to Date

- 1980 committment
  reduce cost of first 54 production tanks by 66M$ for non-recurring cost of 20M$

- Implementation

CY	1980	1981	1982	1983	Total
Plan	2.0	15	32	17	66M$
Actual	1.5	16.7	42.5		

- As of December 31, 1982

Cost reduction examples

- Replace sand castings with investment castings for titanium fittings
- Simplify acceptance data packages
- LO_2 slosh baffle deletion
- Replace SLA dams with rubber dams in cable trays
- Return LO_2 sensors to orbiter
- Replace SLA/SOFI with new SOFI for aft dome

Summary

- 80 candidates submitted to date worth 60.7M$
- 73 approved so far MSFC worth 56.3M$ (firm)
- Additional 75 + candidates under evaluation worth 35.0M$
- Goal completion planned for mid 1983
- Savings through mission model could exceed 450M$

FIGURE 8

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MICHOUD DIVISION

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Work Force Stability

In addition to gradual growth in all categories of the workforce, the 1982 Michoud staffing featured the continuous development of production skills within the hourly workforce. As indicated below, there was a slight change in the skill distribution more aligned with our current and anticipated production requirements:

	1/1/81	12/31/81	12/31/82
Skilled	31.2	23.5	27.9
Semi-Skilled	39.9	34.0	38.4
Operative	28.9	42.5	33.7

169 hourly employees terminated during 1982. 72 or 42.6% were for involuntary reasons. This demonstrates a continuous effort by Martin Marietta to evaluate and selectively retain productive and adaptable employees

Overall, this analysis indicates that Martin Marietta has an extremely good record of retaining highly skilled and motivated long term employees

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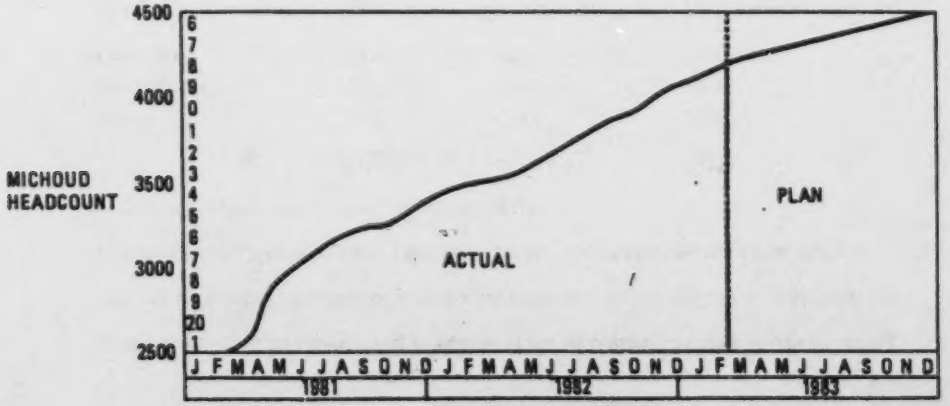
MICHOUD DIVISION

People

ATTRITION

	1977	1978	1979	1980	1981	1982
EXEMPT SALARY	11.5%	16.8%	12.1%	10.8%	11.5%	8.8%
NON EXEMPT SALARY	20.9%	23.0%	23.8%	19.8%	14.4%	16.0%
HOURLY	55.8%	37.5%	29.4%	17.7%	20.8%	13.7%
TOTAL	26.7%	24.2%	18.0%	13.9%	14.6%	11.4%



MICHOUD MANPOWER
(EXCLUDES KSC)

FIGURE 9

MARTIN MARIETTA
MICHOUD DIVISION

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Systems Refinement Teams- an Example of Motivation Efforts Used

Systems Refinement Teams (Quality Circles) represent a planned, organized effort to change, in a positive way, the effectiveness and efficiency of the organization. The goal of this change is participation by employees in decisions affecting their immediate work responsiblilities. The quality of the change is dependent on the cooperation of management, the effectiveness of the implementation plan, and the professionalism, talent and dedication of those facilitating the change. The major payback for this effort is a permanent, long term impact on the organization and its work force stability and productivity

Systems Refinement Teams - Results

- Number of teams

Martin Marietta	54-(513 members)
Martin Marietta Management (MAF & KSC)	2-(19 members)
Martin Marietta, NASA & DCAS (integrated teams)	3-(42 members)
Others (AVCO, AHF)	27-(216 members)

- Improvement projects completed/in work - 226

- Benefits

Hourly SRT members have better records than hourly employees not yet particpating

- Unpaid lost time	37% lower
- Grievances	29% lower
- Safety accidents	34% lower
- Safety incidents	1% lower
- Attitude related attrition	31% lower

Hourly employees are more productive after joining systems refinement

- Unpaid lost time	45% reduction
- Grievances	58% reduction
- Safety accidents	57% reduction
- Safety incidents	68% reduction
- Hardware non-conformances	59% reduction

Integrated Parts Status System

The integrated parts status system is a multi-faceted management tool for the External Tank production. It is utilized from the initial engineering drawing release through planning/ scheduling, procurement/inventory control, accounting, production management controls, and accounts payment. Eleven of sixteen IPSS modules are currently on-line with the remaining five on-schedule for completion this year

Integrated Parts Status System

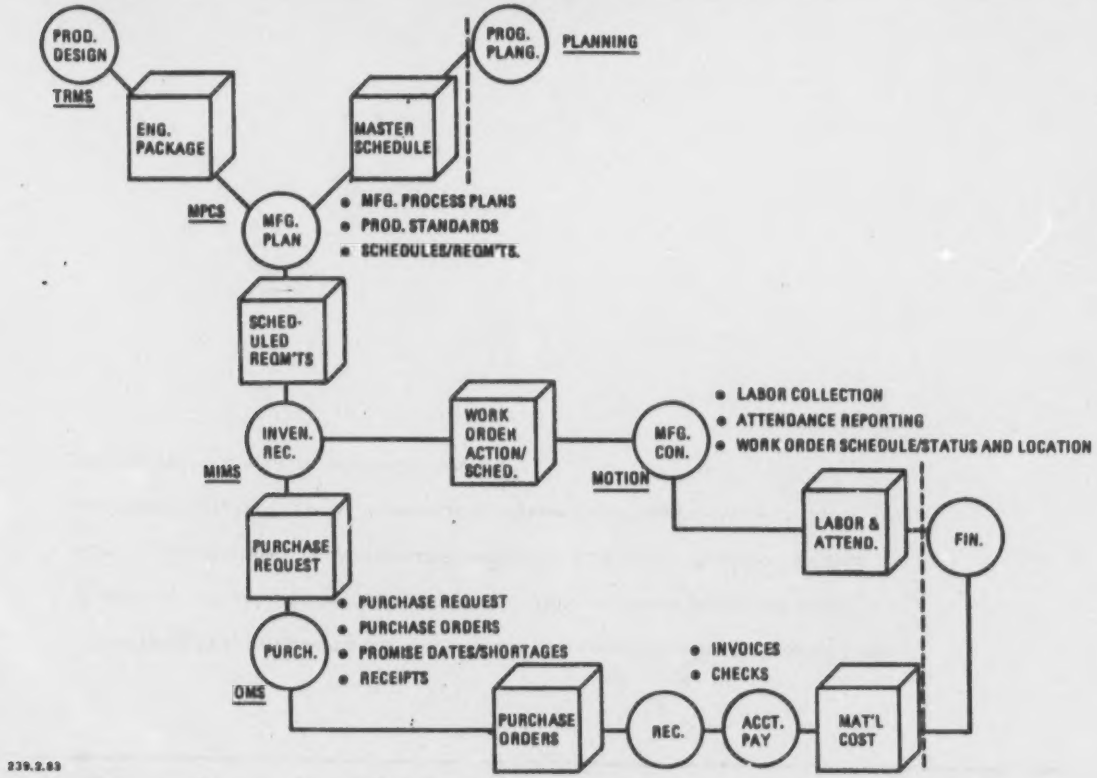

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FIGURE 11

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FIELD HEARINGS

MONDAY, FEBRUARY 28, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Marshall Space Flight Center, Huntsville, Ala.

TRANSCRIPT OF TESTIMONY

of

DR. W. R. LUCAS
DIRECTOR, GEORGE C. MARSHALL SPACE FLIGHT CENTER

CHAIRMAN VOLKMER: The Subcommittee will come to order please. The Subcommittee on Space Science and Applications continues its review of the NASA Fiscal Year 84 Budget Request. Briefings and discussions will become a part of our formal hearing records. The Marshall Space Flight Center can be proud of the significant contributions it has made to our nation's space program. Today we hope to gain a better understanding of the overall mission of Marshall and the problems which the Center management perceives in accomplishing the mission in addition to reviewing the status of the Shuttle activities. We will also discuss future directions and goals for the agency. We are pleased to have the opportunity to visit Marshall Space Flight Center and look forward to the briefings and the facilities tour. We are also very pleased that your local representative, my good friend, Ronnie

Flippo, has joined us today. I can assure you that Congressman Flippo has done an outstanding job in Washington, D.C. and has taken care of your interests. At this time, I would like to recognize the Ranking Minority Member of the Subcommittee, who is an outstanding member of Congress, Congressman Mannie Lujan, of New Mexico.

CONGRESSMAN LUJAN: I don't have a prepared statement, but I'm just delighted to be here, Ron. Marshall certainly has a very prominent place in the annals of space history. I have been wanting to get down here for a long time. I'm new on the Subcommittee on Space, so this trip for me has been quite an education. We started off at Johnson down at Houston, then went to New Orleans to Michoud to review the External Tank, yesterday afternoon we went to NSTL where you test the engines, and today we're here at Marshall. So in four days we have had a very good orientation; I'll see how much of all of this I can remember and use in working on the Subcommittee. We look forward to all your comments.

CHAIRMAN VOLKMER: Ronnie, do you have a statement?

MR. FLIPPO: Mr. Chairman, thank you for giving me an opportunity to be with you today. Harold, Mannie and the staff, let me say on behalf of the community that we are very appreciative of the fact that you could take time at this point during the year to go around and look at the Centers. We're very proud of this Center that is located here in Huntsville, Marshall Space Flight Center. We're very proud of Bill Lucas and the people that he has assembled to do this job and the contributions that this Center has made to the space effort throughout its history. I think you will find, I know you will find here, a group of people willing to go the extra mile and serve as a

dedication to the nation in order to accomplish the mission that the nation defines for it to accomplish. May I say a word or two to the Center folks that are here about Harold Volkmer and Mannie Lujan. I've known these men for a number of years. They are hard-working men, they will take the time that is necessary to be well informed; they will make the right decisions at the right time. I'm very pleased that you all could come here. Most of all I'm very pleased that Mrs. Lujan saw fit to come today. We have been on some of these tours together and I'm delighted that she could come down here as well. I look forward to the hearings and look forward to working with you.

CHAIRMAN VOLKMER: Thank you very much, Ronnie. Now at this time I recognize Dr. Lucas. Dr. Lucas, do you have a prepared statement that will be made a part of the record at this time? You can either review that or summarize. As far as the other witnesses, I would like to say, too, that their statements will be made a part of the record. Dr. Lucas.

DR. LUCAS: Mr. Chairman, Mr. Lujan, Mr. Flippo, we are certainly delighted that you would come to the Marshall Space Flight Center. On behalf of all my colleagues, those in this room and those throughout the Center, I want to welcome you to Marshall Space Flight Center and to express our deep appreciation to you for the leadership that you have provided and continue to provide to our nations's space program, a program to which we have dedicated our professional lives. Before we begin our testimony, Mr. Chairman, I would like to call on Mr. Michael Weeks, our Deputy Associate Administrator, Office of Space Flight, who is with you and with us today to see if he has a word to say. Mike.

MR. WEEKS: Chairman Volkmer, Mr. Lujan, Mr. Flippo. You are visiting another crown jewel, in my opinion, of NASA and really, perhaps more importantly, the United States of America. This George Catlett Marshall Space Flight Center grew out of a very capable German effort at Peenemuende, and then at the end of World War II, Project Paperclip brought those folks to White Sands, New Mexico, where I believe they launched a V-2 or two or three. Then Dr. Wernher von Braun and his team became a part of the Redstone Arsenal which was the Developmental Operations Division, out of which grew this present Marshall Space Flight Center. As Dr. Lucas will tell you, this operation was responsible for our first satellite in orbit, but more importantly in my view, the Saturn I and then the very famous Saturn V which, in 11 years after NASA was organized in 1958 to 1969, put two men on the moon, and was the major capability that made that possible. And, of course, was capable even in '69 of delivering a quarter of a million pounds to low-orbit and 90 thousand pounds to geosynchronous orbit and, Mr. Lujan, we've been telling you about 5,000 pounds and NASA was capable in '69 of 90,000 pounds to GEO. And, of course, since that they are the propulsion group for the Shuttle, the main engine and the external tank—which you have seen—and the solid rocket booster, which you have not yet seen. So the propulsion part of the Shuttle is Marshall's responsibility, and it has done very well indeed. And, of course, this is our 25 year anniversary of NASA since 1958 when it was organized. Dr. Lucas is the fourth Center Director following the great heritage of von Braun and his successors. I'm pretty impressed with the outstanding, competent capability that exists here in what I call this another of the crown jewels of the United States. Thank

you.

DR. LUCAS: Thank you, Mike. I am certainly glad I called on you first. Mr. Chairman, the proceedings are being recorded. In addition to that, we will transcribe it for the record. You have observed that our prepared statements will be accepted for the record, and with that in mind I'd like to request permission to summarize our statements. We have prepared some charts for that purpose, and they are on the table before you.

Since this is your first visit to the Center, I plan to provide a brief overview of facilities and what we've been doing in the recent past. This is a map (Figure 1) showing the Center which is situated essentially in the center of Redstone Arsenal. The Arsenal reservation consists of some 38,000 acres, and we have over 1,800 acres. We enjoy a very good relationship with our Army neighbors who surround us. We make joint use of certain facilities and we buy certain support from the Army. In addition to that, from time to time, we have occasion to help them with their problems, and they help us on occasion. So we have a very good relationship.

Another important aspect of our environment is the area identified on the map as the Cummings Research Park. This is an industrial zone in which most of the aerospace contractors have facilities, varying from small offices to rather extensive facilities, in some cases large enough for producing hardware. It is valuable to have them in such close proximity to the Center. The Alabama Space and Rocket Center, near us on Highway 20, serves as the Visitors Information Center for the Marshall Space Flight Center and also does a very fine job in presenting the space program to the

general population. It is one of the most attractive tourist sites in Alabama. At the location outlined in red on the chart is the University of Alabama in Huntsville. This is a very fine university, young in years, but very important in terms of its quality. There are about 6,000 students in this university, many of them at the graduate level. They have graduate programs offering degrees through the Ph.D. in physics, engineering and computer sciences. In addition to that university, we also have Oakwood College, a small church school of about 1,400 students, and Alabama A&M University with about 4,500 students. The total university population in Huntsville is about 12,000. The Huntsville/Madison County Jetport is a very important part of our transportation system, as is the Redstone airstrip which we use jointly with the Army. These provide good air transportation facilities. The Southern railroad parallels Highway 20, and we have water transportation via the Tennessee River. We can ship from here to Michoud Assembly Facility, to the National Space Technology Laboratories for engine testing, and to the Kennedy Space Center, as will be shown on a subsequent chart. The Center is situated about five miles from the Tennessee River and there is a broad road bed built for movement of Saturn stages that provides access to our docks located there.

This is an aerial view of the Center (Figure 2) looking from the north to the south. We are meeting in the top floor of the building in the center of the photo, which is our Headquarters area. In these three buildings are located the staff offices, the Administration and Program Support activity, the management of the Science and Engineering Directorate, all our Project offices and our Program Development group. To the south you see the

remainder of our facilities. The engineering facilities are in the center background. Our industrial areas, assembly and checkout areas are to the right. In the distance toward the Tennessee River is our rocket test area.

The next photo (Figure 3), showing our test area, is taken from the south toward the north. In the foreground is the test stand that was originally used for Saturn IB rocket static testing. It is in mothballs as far as rocket testing is concerned, but in the flame trench we have placed a stress frame for use in the structural test of the Shuttle Solid Rocket Booster. That test setup was located there because we had 6,000 channels of instrumentation already in this test stand and a full control center situated close by. All we had to do was connect the instrumentation for the required channels of data. In the left background is the test stand which provided the Saturn J-2 engine liquid hydrogen/liquid oxygen test capabilities. The tower in the right center is unique. It is the dynamics test stand in which we tested the Saturn V dynamically, and where we subsequently tested the Shuttle. The Shuttle was stacked in launch configuration for the first time in this facility, the Solid Rocket Boosters, the External Tank and the Orbiter, and there it was dynamically tested in different configurations of launch and flight. You may notice the different color in the building wall. We had to expand that building a bit to take advantage of the foresight of some of the planning in the past. The tower was first built for test of Saturn V but in the initial construction the foundation was placed for a larger building in anticipation of development of the Nova rocket. Although we never developed a Nova, we did use those same footings to extend this building, at a great cost savings, to dynamically test the Shuttle.

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Computer-Aided Design

The initial work station installations will be completed in mid - 1983. Work stations will support Engineering, Production Operations, Quality Control, Facilities and computer applications. Training and Procedures Development are on-going with pilot program operations to commence during the 4th quarter 1983 and consist of:

- Anomaly and liaison call disposition
- Tool and facility design
- Critical system configuration control

CAD/CAM

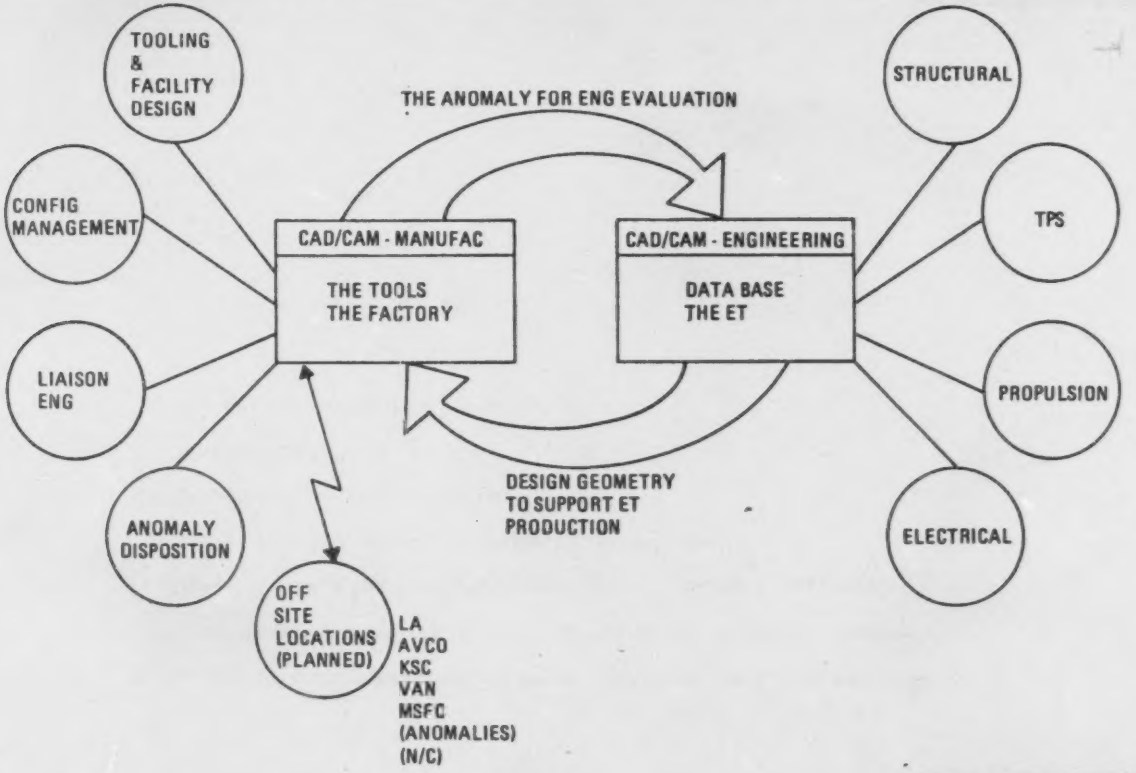

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FIGURE 12

MARTIN MARIETTA
MICHOUD DIVISION

Summary

- Five flight articles have flown successfully, three are at KSC being prepared for flight, and nine are in assembly at MAF
- The private sector support national award and the defense logistics agency national award were received in 1982 for small disadvantaged business programs
- A production rate of 24 tanks per year can be achieved as required by 1987, and future growth to the maximum mission-model rates can be accommodated
- Increased production rate requires computerized IPSS and will greatly benefit with the implementation of CAD/CAM
- Productivity has been increased through programs of producibility, production readiness and "quality of work-life" programs
- Funding requirements continue to be well coordinated with the NASA program office and prior-year funding marks have been met with precision
- The commitment to mission success remains the dominant theme at Michoud

You will see throughout the Shuttle program, not only at Marshall but around the country that we have utilized facilities already in place, consequently saving great amounts of money. To your left in our west test area is the Saturn V first stage (SI-C) static test stand. We are not using that for active propulsion testing now, but we have moved the flame bucket away and have used this large structure as a stress frame for structural testing of the hydrogen tank of the Shuttle External Tank. In the background are high-bay areas and another structural load test facility which, will be shown better in subsequent charts.

This chart (Figure 4) shows a better view of some of our test facilities. If time and weather permit we will drive through the test area later today. In our acoustic model test facility we fire live motors, to measure the resulting acoustic environment. In the stand is the 6.4% model of the Orbiter with liquid rocket motors as well as the solid rocket motors. The data acquired is used in launch vehicle design as well as in the design of the launch pedestal. We have completed the work as it affects the KSC launch facility but we are now working vigorously on the launch pedestals for Vandenberg Air Force Base. The view of the dynamic test tower, that we have already discussed, is down from the top of this facility, which is about 425 feet high. The Orbiter nose is visible adjacent to the tank. In the lower left is the SI-C Test Stand where we tested the hydrogen tank. The lower center photo is made inside the large structural test facility where we do structural mode testing. In this view is the liquid oxygen tank of the Shuttle External Tank. The lower right photo is a view down into the stress frame for testing of the Solid Rocket Motors. The roof of the building is lifted off

with a crane, and we lower the test item into the frame for structural test for the various regimes during flight.

The next chart (Figure 5) shows some special facilities that we believe are important as an asset to the Agency and to the country. The small wind tunnel, a very high Reynolds number facility, about 200,000,000 and mach 1.25, has been unique until recently in our country. It has a 32 inch throat; it is small but quite useful. The Neutral Buoyancy Tank is a distinctive facility that has been very effective in testing designs of equipment to be built for use in space. Engineers can practice the functions that they are designing for and get a better perspective of how to design the hardware to be used in space. Another unique facility is our X-ray Telescope Calibration Facility. This facility was built specifically for the High Energy Astronomy Observatory (HEAO). We utilized part of an existing building and then added a long tube 3 feet in diameter and about a thousand feet long. This tube is evacuated and an X-ray source located at the end of the tube is fired down the tube, and the instrument located in a vacuum chamber at the opposite end of the tube is calibrated. It provides a very effective capability.

As you know, much of our work is done by contractors scattered around the country, and to a degree, the world. At each place where we have a major prime contractor, we have a resident office on-site to keep abreast of efforts in the contractor plant. You see those locations indicated on this chart (Figure 6). I want to call your attention to the fact that we also have a resident office in Europe where the Spacelab is being developed and manufactured. We have about 130 people located at these resident

offices.

The next chart (Figure 7) shows that, in addition to those resident offices and our Center headquarters, we have other component facilities. This map also shows our outlet to the sea through the Tennessee, Ohio, and Mississippi Rivers to New Orleans, to the Mississippi test site and through the Gulf to the Kennedy Space Center. That's important for our large hardware such as the External Tank because that's the only way it can be transported.

Since you visited the Michoud Assembly Facility (Figure 8) on Saturday, I will not discuss it although it is an important and effective facility.

We have another facility that you passed by on Saturday. Located off Interstate 10 between the Michoud Assembly Facility and the National Space Technology Laboratories is our Slidell Computer Facility (Figure 9). This was formerly an FAA facility which we acquired in early 1962. We placed a computer facility there for automatic data processing associated with efforts at the Michoud Assembly Facility and our engine testing at NSTL. We still use it for support of Michoud and NSTL activities and we also have it connected to our computer facility here in Huntsville so that we can off-load both ways. It provides a very effective adjunct to our computation capabilities. In addition to our own work, we have some 150 people there that support other agencies of the government. We are reimbursed for work done for other agencies.

Since you visited NSTL (Figure 10), I won't dwell on that facility. In the foreground is the stand formerly used for the Saturn SI-C testing, and now used for Shuttle Main Propulsion System testing. The two stands in the

background were built originally for the Saturn S-II Stage and are being used for the Shuttle single engine testing. The canals up to the stand allow us to transport fuel and other hardware by water to this site. This provides for very effective transportation.

On the next chart (Figure 11) we have attempted to summarize the Center heritage, the history and the anticipation of the future on one chart. It represents what we have been involved in since the decade of the 1950's. We became the Marshall Space Flight Center of the National Aeronautics and Space Administration on July 1, 1960, but we were actually working on space programs before that time. The nucleus of what became the Marshall Space Flight Center, worked as a team for the United States Army in developing ballistic missiles, and near the end of the decade we translated these ballistic missiles into space launchers. The Redstone Missile, modified slightly, launched the Mercury capsule, but before that time, the Jupiter C, which was made by adding three more stages to the Redstone Rocket, launched the first Explorer. We are very proud of the fact that we were able to launch the very first satellite of this country, the one which really inaugurated the space age for the United States. In addition to developing the rocket itself, we developed the spacecraft, that is the Explorer I, a cylinder of about 6 inches in diameter and about 7 feet long. The Jet Propulsion Laboratory which also worked for the Army at that time developed the instruments and packaged them in such a way that they could be placed inside this cylinder. I well remember the celebration on the night of January 31, 1958, when the word came that we did have our satellite in orbit. There was quite a celebration on the town square. I am told by some

of the old timers, very old timers, and they probably heard the story from others, that this celebration is rivaled in its spontaniety and intensity only by one other event in Huntsville's history. That was the arrival of General Nathan Bedford Forrest in Huntsville during the Civil War. I don't know whether that is fact, so I'd like to have that recorded as conjecture in my testimony.

The decade of the sixties was heavily devoted to the Saturn family of launch vehicles. But importantly, along with the development of these rockets, we were also developing some spacecraft as well. We developed the Pegasus satellite, three of which were flown in the early sixties to characterize the micrometeoroid environment of space. They were flown on the Saturn I vehicle. In the late 60's, we developed the Lunar Roving Vehicle, and we began developing the Skylab which flew in 1973 and was used in orbit through the first part of 1974. In the 70's, we worked extensively on the Space Shuttle propulsion system which we will discuss in more detail during the course of the day. We have also been responsible for several important payloads. We are responsible for and we will discuss Spacelab later today. We were responsible for the High Energy Astronomy Observatory program. These three spacecraft that were developed and flown in the late 1970's taught us much more about the X-ray character of the sky than had been known before. Although the last flight was in 1979, the data generated from those three spacecraft, with which we located and measured sources of X-rays, cosmic rays and gamma rays, are still being analyzed. The Space Telescope which will be discussed later today, the Space Processing Applications Rocket, a gravitational physics payload for

studying some of the fundamental aspects of Einstein's theory of relativity are also projects of MSFC. The LAGEOS project was an in-house project developed to study the movements of the earth's crust in time. The projects shown for the 1980's will be discussed from Bob Marshall's presentation later today.

The Center organization has been stable since the last visit of the Subcommittee. There have been no significant changes in the organization. The blue corners on the blocks indicate where there have been significant personnel changes, resulting from retirement and from our practice of moving people from a job to another opportunity for the development of the individual as well as for the good of the organization. I'll use this occasion if I may, sir, to introduce some of my colleagues who are here, some of whom will be speaking to you later today. My deputy director, is Jack Lee, and the Associate Director position is vacant at this time. However, we also have in this block two very important individuals, one of them, Woody Bethay, whom you have met, is the Executive Assistant Director of the Center. Bill Sneed, the Assistant Director for Policy and Review, is a new appointee since the last visit. The Associate Director for Science job is vacant at this time. Our Safety Office is headed by Dick Henritze, and our Public Affairs Office has a new director, John Taylor replacing the previous director who retired. Our Chief Counsel, Mrs. Susan McGuire Smith, was formerly the Deputy Chief Counsel, but has been advanced to Chief Counsel within the past year. The Center Comptroller, Jack Swearingen, was advanced to that spot from another key assignment at the Center when our former Comptroller left for private industry. The Personnel Office is

headed by Don Bean, and the Equal Opportunity Office is headed by Clyde Foster. At this point I want to note that we have made very significant gains in the Equal Opportunity area. We have, during the course of the last two or three years, made significant improvements in terms of recognizing and advancing minorities and women, although still not as much as we would like. We've done very well I think in recognizing those already in our work force. However, we have not been able to employ as many as we planned because we have difficulty competing with salaries that the caliber of people we want can demand from other employers. We have done exceptionally well, I believe, in supporting the small and disadvantaged business community. For example, in FY-82 we obligated to small and disadvantaged business a total of about $49.8 million which was a 106% of our goal, and within that amount we also exceeded our goal for disadvantaged business. I believe we did exceptionally well in that regard.

We manage our programs at the Center by using a small project staff which calls upon our institutional components in a matrix fashion to get the job done. Heading the Shuttle Projects Office, to which the Michoud Assembly Facility is attached, is Bob Lindstrom. Bob will be speaking to you later today about the Shuttle Projects, and he'll be introducing at that time his subordinate managers for the various elements of the Shuttle for which we are responsible. Special Projects Office is headed temporarily by Jack Lee. The Space Telescope Project Office is headed by Dr. Fred Speer, who will be speaking to you later today. The Spacelab Program Office is headed by John Thomas and Spacelab Payload Project Office by Jim Downey.

The bulk of our work force is in our institutional elements. The

director of Program Development is Bob Marshall. He'll be speaking later about some of the advanced programs that he is working on. His is a small organization, but a very effective and important one because it is from the leadership of this organization that our new programs emerge. In fact, out of this organization have come all the projects on which we are working today. Program Development handles the feasibility and the preliminary design and definition phases of potential new programs. When the program becomes an approved program, a project office is formed for the implementation of the project. The Director of Science and Engineering is Jim Kingsbury. This is where we have most of our engineering and science capability. About 1,950 people in this organization are arranged in the various disciplines represented on the chart. Our capability is predominantly engineering, but we also do have a very effective Space Science Laboratory. We have a new director of that organization, Dr. Alexander Dessler, who was formerly at Rice Institute of Houston. He has joined us during the last year to replace Dr. Lundquist who retired. J. N. Foster heads our Administration and Program Support Directorate. Jay was formerly the Deputy Director of this organization and he replaced Jim Murphy who retired since the last Subcommittee visit. In Mr. Foster's organization, we have important administrative functions including the procurement office and other functions that are indicated on the chart.

Our total work force is essentially stable at approximately 3,335 people. As a result of retirements and attrition during the last couple of years we've been able to employ about 200 "fresh-outs," or entry-level engineers and scientists. We consider it essential to our future and the

future of the agency to employ new people. The Marshall Space Flight Center is still the Center with the highest average age although we have been able to bring that down by more than a year in the last two or three years by employing some entry-level people. We're pleased that we have had that opportunity.

This chart (Figure 13) shows a profile of our work force. Of our total of about 3,335 employees, 2,248 have an earned degree. Of that number 105 have earned doctorates, and 438 have at least one earned masters. The disciplines of our people are varied, as indicated by this chart, (Figure 14). The largest number of people with degrees have them in engineering, but a significant number are in science and in other disciplines. Of the engineering people, the highest number are electrical engineering, mechanical being next, and so on as indicated on the chart. Within our science disciplines, the preponderant number are in physics and mathematics.

The next chart (Figure 15) is a summary of what we consider to be our areas of technical excellence. These include the management of complex programs such as those that we will be discussing with you today, systems engineering and integration functions, systems development, and particularly in the integration of payloads. This is an increasing function. Our technical disciplines are propulsion, structures, materials science and engineering, electronics, power systems, and data systems. In addition to these functions which are primarily engineering, we have selected certain areas for building cells of excellence in science. These cells of excellence include solar terrestrial, astronomical science, relativity physics, and materials processing in space. As I mentioned previously, we do not have a large staff

in this area, but I believe there is excellent quality in these small cells. We strive for this capability for at least two reasons; one is to make a contribution to the space sciences, but perhaps equally important to enable us to communicate properly with the scientific community that we serve by the development of spacecraft and by the transporting of spacecraft into orbit. A scientist communicates better with another scientist than he does with an engineer, and we believe our effectiveness in managing certain programs such as the High Energy Astronomy Observatory and the Space Telescope has been increased by having some in-house scientists for that purpose.

This next chart (Figure 16) lists our projects in three categories; approved for implementation; assigned for definition; and proposed for future, those for which we are conducting feasibility studies. The Space Shuttle and the support that we provide to Space Transportation Systems operations will be discussed in detail by Bob Lindstrom. The Space Telescope will be discussed by Dr. Fred Speer, and these other programs which are approved for implementation I will summarize for you. We have the experts here who can respond to any questions you may have. Bob Marshall will cover advanced program areas in a special presentation.

I'll begin with the Inertial Upper Stage, IUS. The Inertial Upper Stage (Figure 17) is being developed by the Air Force with the Boeing Company as the prime contractor. It is being developed for Air Force use as well as for NASA use. We represent NASA in working with the Air Force in this development and are responsible for the IUS vehicle that will be flown in the months just ahead. The first NASA IUS will be flown on the next Shuttle

flight, STS-6, carrying the Tracking and Data Relay Satellite. A review last week indicated that the IUS is ready for that launch. The IUS and satellite will be carried in the cargo bay of the Shuttle and will be launched as the primary mission of STS-6.

Spacelab (Figure 18) is a collaborative effort between the U.S. and the European Space Agency. We at Marshall represent NASA in dealing with the European space community to develop the Spacelab, a very flexible vehicle. It consists of pressurized modules and experiment mounting racks, which are designated as pallets, that hold experiments that need to be exposed to the space environment. Spacelab can be flown as a pressurized module, a combination of pressurized module and pallet, or in the pallet-only mode. When we have only a train of pallets, we use a component, the igloo, which is really an instrumentation package that allows communication from the Orbiter flight deck with the experiments on the pallet. All of these elements are designed and contributed by the European Space Agency for the first flight unit. The tunnel that allows the crew to move between the flight deck of the Orbiter and the Spacelab is a U.S. development. The payload specalists will work in the pressurized module. They will live, sleep and eat, etc. on the flight deck of the Orbiter. This program has gone well and while there have been the normal kinds of problems that one would associate with a rather complex management relationship, we now have hardware ready to go which we expect to fly this fall. This photograph (Figure 19) is a scene in the operations and checkout building at the Kennedy Space Center where the pressurized module is now located. The next photograph (Figure 20) shows a payload rack mounted to the module floor.

All of that assembly is inserted into the cylinder of the pressurized module after the experiments are checked out and ready to go. We are now in the process of buying the second flight unit from the European Space Agency.

Another important function relative to the utilization of the Spacelab is the mission management responsibility (Figure 21). The user community for Spacelab includes people from universities and from small research institutes, some of whom are not accustomed to dealing with the space program to the extent that would be required to fly in this vehicle. Consequently, the agency has developed a concept wherein the mission management role is assigned to a NASA Center and that Center represents the user to the Space Transportation System. Marshall Space Flight Center has been assigned that role for the first three missions of Spacelab. The fourth mission is assigned to Johnson Space Center. The sixth mission has been assigned to the Marshall Center also. This mission management function is a role that is rather demanding and important. For example, on the first mission there will be 38 different experiments flown, about half of them European and half of them U.S. and they must be integrated so as to operate properly together and within available resources. While the primary purpose of the first two Spacelab flights is to checkout the Spacelab systems themselves, useful science will also be accomplished. The third mission which will be almost a totally pressurized module is being developed and it will be devoted largely to materials processing in space. It will be flown before Mission 2, and is now scheduled for September of 1984. The second mission will fly in early 1985 under the present plan.

In addition to these complete payloads, we are responsible for several

partial payloads. This chart (Figure 22) shows one which is designated as OSTA-2. This is not a full rack; the frame is a structure that is mounted to the cargo bay of the Shuttle and on which are placed various experiments that are to be operated in space. This particular partial payload will consist primarily of materials processing in space, a combination of U.S. and European, primarily German experiments. Another example of these assignments is a similar one, OAST-1 (Figure 23). On it will be a solar array experiment under the auspices of the Office of Aeronautics and Space Technology. A third group of missions, just recently assigned, are the ASTRO missions (Figure 24). These are missions in spectrophotometric and spectropolarimetric studies of stars and galaxies. The first mission will carry primarily ultraviolet experiments. In addition to Spacelab, full Spacelab missions, and partial missions such as these just described we are responsible for some individual experiments.

We believe and have believed for a long time that materials processing in space has a great potential (Figure 25). We have been working in this field for a number of years and our studies have been devoted to gaining fundamental knowledge as to the effect that the absence of gravity may have on certain processes. One objective has been to better understand processes in the space environment so as to improve processes here on the ground. We also believe that there may be some processes where production of materials can only be accomplished in space, and we hope that our initial experimentation will identify those. We are also devoting attention to commercial opportunities for processing in space, because we believe that not only in materials processing but in other applications that the full

realization of the taxpayers' investment will be gained only by commercialization. This next chart (Figure 26) indicates how we are approaching the experiment program. We have utilized our dynamics test tower where we have installed a drop tube in which we subject experiments to about 4-1/2 seconds of zero-g for initial studies. The next step up is to use the zero-g airplane which can provide about 30 seconds of very low-g. The next enhancement is the SPAR, a sounding rocket program that we have done in conjunction with the Goddard Center. Goddard launches the rocket which carries the payload which we develop. It will provide about 6 minutes of low-g in flight. Spacelab, and ultimately a space platform, will provide the opportunity for extended time for the application and commercialization. The next chart (Figure 27) lists processes that are affected by the disturbing influences of gravity, where research is focused. These include crystal growth processes, solidification processes, and containerless processing. Biological separation processes is the area that seems to be most likely to be an early application. It is the area in which the McDonnell Douglas Corporation in conjunction with the Ortho Division of Johnson and Johnson have made a joint venture agreement with NASA and have already demonstrated effective separation of biological materials. The processing equipment will fly again and be operated on STS-6.

MR. FLIPPO: Dr. Lucas, excuse me for interrupting. Could you tell us what the Europeans or Japanese are doing in terms of materials processing compared to what we are doing; what kind of effort they are putting in?

DR. LUCAS: At this moment I can't give you a total expenditure comparison, but can probably get reasonably useful data on that for you.

Particularly, the Europeans are more vigorous, I believe, in their pursuit of materials processing in space than we are in this country. The Japanese were a little later in starting, but are accelerating their efforts very rapidly in this area. As an example, the Germans will have some experiments on the very first Spacelab and on OSTA-2. I believe I would have to characterize them as being very aggressive, perhaps exceeding that of this country.

MR. FLIPPO: Would it be appropriate, Mr. Chairman, to request the agency to provide any information they have for the record so that we can compare the level of effort of the U.S. in regard to materials processing versus the Europeans or Japanese?

CHAIRMAN VOLKMER: If the agency is able to provide it, we'll do that.

DR. LUCAS: I think we will be able to give an approximation. We may not be able to give precisely what they are doing, but at least in an order of magnitude.

CHAIRMAN VOLKMER: And the areas in which they are working.

DR. LUCAS: We will be glad to provide that to you for the record.

In addition to what we do within our own laboratory, I want to mention our efforts with industries. With the McDonnell Douglas Astronautics Company in the field of continous flow electrophoresis, we have a joint agreement where there is no exchange of funds. The company develops the hardware and develops the experiment, while NASA provides the flight. We also get to use the equipment to an extent and ultimately the company gets the advantage of the results for commercialization. The first experiment was flown on STS-3, and the continuous flow electrophoresis process

demonstrated that it could separate biological substances some 400 times faster than is possible on the ground, and perhaps more effectively. Microgravity Research Associates is beginning to develop another joint agreement with NASA at the present time. In addition to those joint agreements we have for flights and for developing flight hardware, we have some work within our own laboratories, ground processing work where companies are participating. This chart (Figure 28) gives a list of so ne of them and their interest. For example, Deere and Company and Bethlehem Steel are working on the formation of graphite in cast iron. I wouldn't want to imply that we will ever make cast iron in space, but there may be some fundamental knowledge that can be gained about the influences of the formation of graphite in cast iron that could be applied effectively here on earth. I believe it is important in these days of decreasing availability of high alloy steels and high strength materials that we learn how to use more effectively some of the things that have been around a long time, and cast iron may be one of those.

As I have mentioned, in addition to the complete Spacelab and partial payloads, we are also involved heavily in developing individual experiments (Figure 29). We do some of these for our own scientists and some for scientists with which NASA has an arrangement. In some cases, we are the principal investigator and in some we are the co-principal investigator with another organization and we simply do the engineering development for them. I don't propose, due to the shortness of time, to discuss all of those listed. Our total involvement now is in about 40 different experiments. Three of those listed, incidentally, will fly on STS-6.

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In addition to those activities devoted to flight projects, we also maintain our effectiveness by in-house supporting research to keep our work force sharp, and to make a direct and immediate contribution to flight programs and also to prepare for the future, so that we will be smart buyers when the time comes to start new projects. The areas in which we maintain our expertise (Figure 30) are these: chemical propulsion, large structures, electronics, activities in the sciences as I have mentioned, and in materials processing. It is difficult to quantify effectiveness in this area, but within the last fiscal year, over 230 publications and presentations were made, 89 articles were accepted for publication in the archive journals and 11 patents were granted. Those statistics are but one way of assessing the degree of effectiveness of our supporting research and technology.

Mr. Chairman, that completes the brief overview. I'll be happy to answer questions.

CHAIRMAN VOLKMER: I have no questions at this time, but perhaps we could go through the full presentation and then we will get down to questions on the specifics.

DR. LUCAS: I now present, Mr. Chairman, Bob Lindstrom who is the manager of our Shuttle Projects Office to address the Shuttle.

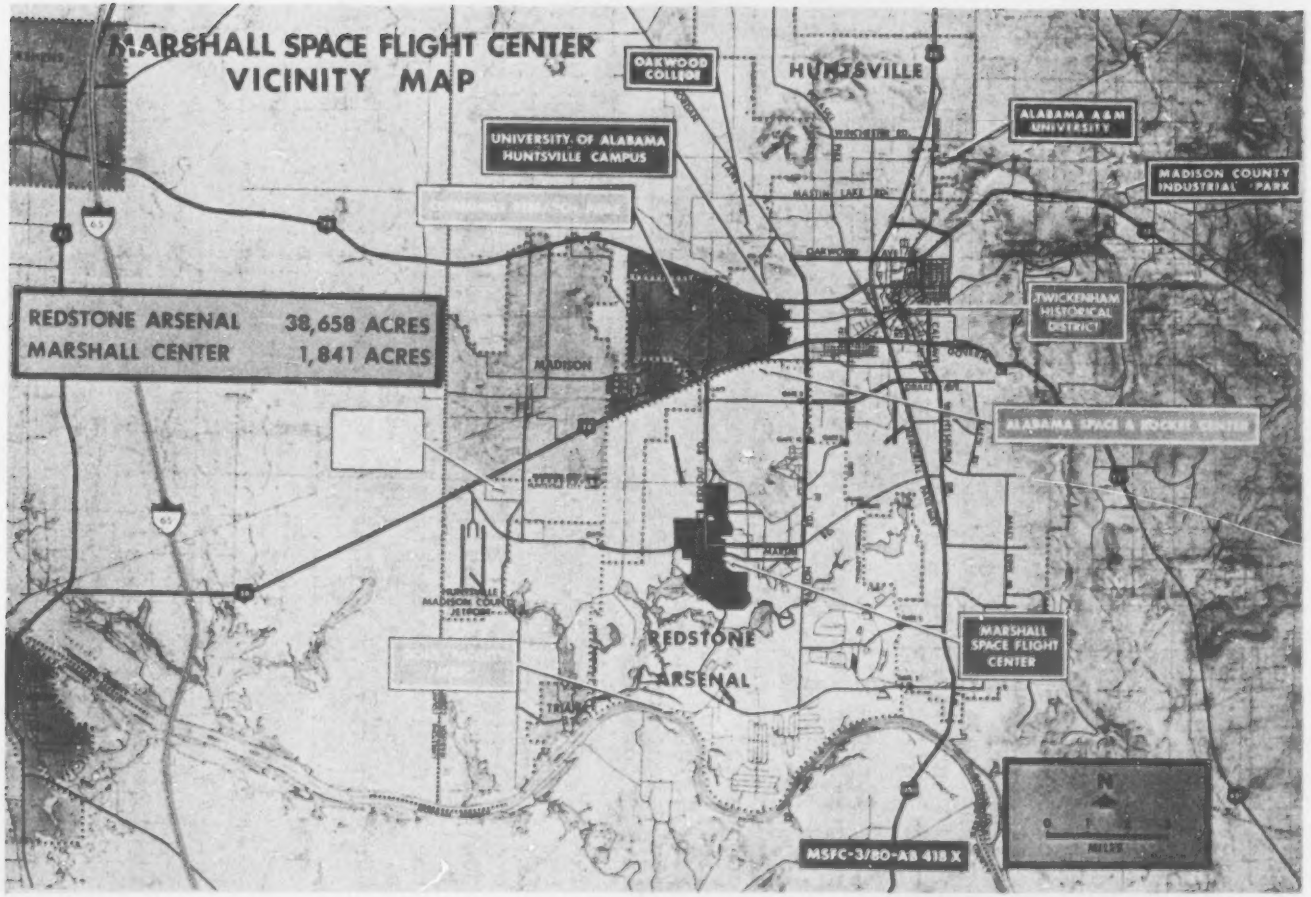
[The information requested on p. 21 by Chairman Volkmer, plus figures 1-30 of Dr. Lucas' oral presentation follow:]

Material requested for the record on page 21 by Chairman Volkmer during the hearing before the House Subcommittee on Space Science and Applications, February 28, 1983.

The U.S. Materials Processing in Space (MPS) program is a multi-discipline activity that includes research and development in crystal growth, solidification, containerless processing, biological separation, and fluid and chemical processes. The R&D activities consist of both NASA-funded work and commercial activities funded by private industry. NASA's expenditure is approximately $22 million per year, and it is estimated that private industry is expending $7 to $10 million per year on commercial MPS activities.

The European MPS activities are dominated by the programs in Germany and France. These programs are very active and aggressive. It appears that they are focused on R&D crystal growth and solidification and the associated fluid phenomena; however, they do have commercial involvement with private industries. Our limited knowledge of the programmatics of the European activities indicates that their expenditures are equivalent to or greater than those in the U.S. and have a potential for growing in the future.

The MPS program in Japan is not as advanced as either the U.S. or Europe; however, they have a program plan which leads to a Shuttle flight in late 1988. This program encompasses crystal growth, solidification, and containerless processing, but it does not appear to include biological separations. It is estimated that the Japanese expenditure is considerably less than either the U.S. or the Europeans' at this time; however, it is growing rapidly.


MARSHALL SPACE FLIGHT CENTER
VICINITY MAP
OAKWOOD COLLEGE
HUNTSVILLE
UNIVERSITY OF ALABAMA HUNTSVILLE CAMPUS
ALABAMA A&M UNIVERSITY
MADISON COUNTY INDUSTRIAL PARK
TWICKENHAM HISTORICAL DISTRICT
REDSTONE ARSENAL 38,658 ACRES
MARSHALL CENTER 1,841 ACRES
MADISON
ALABAMA SPACE & ROCKET CENTER
REDSTONE ARSENAL
MARSHALL SPACE FLIGHT CENTER
N
MSFC-3/80-AB 418 X

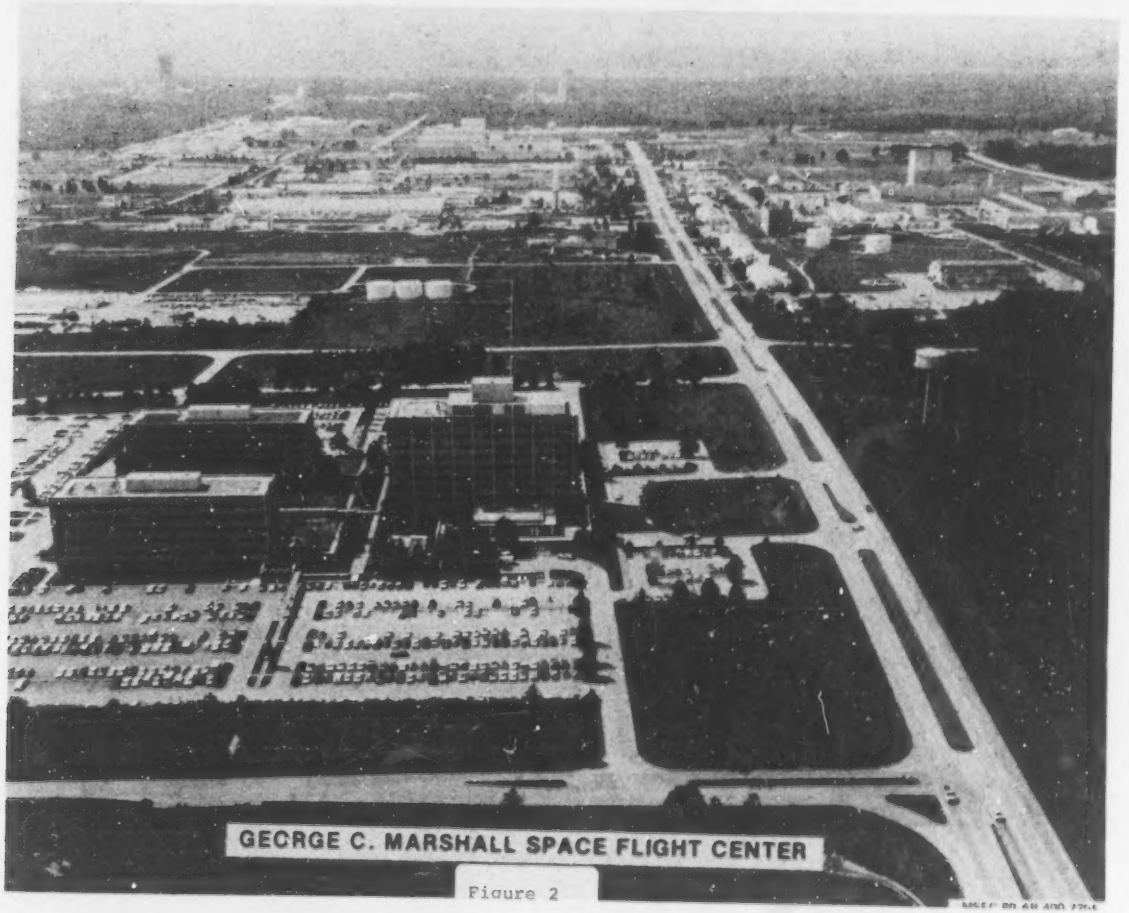


Figure 2

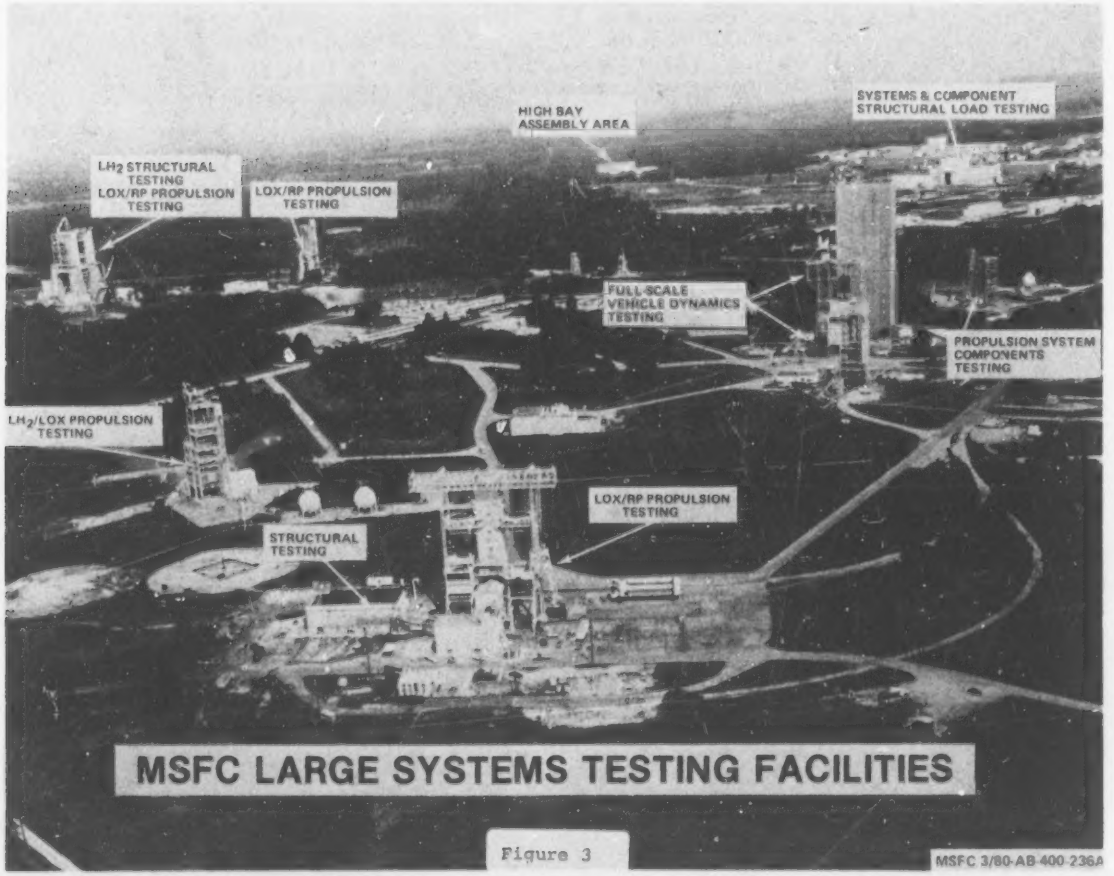

HIGH BAY ASSEMBLY AREA
SYSTEMS & COMPONENT STRUCTURAL LOAD TESTING
LH_2 STRUCTURAL TESTING
LOX/RP PROPULSION TESTING
LOX/RP PROPULSION TESTING
FULL-SCALE VEHICLE DYNAMICS TESTING
PROPULSION SYSTEM COMPONENTS TESTING
LH_2/LOX PROPULSION TESTING
LOX/RP PROPULSION TESTING
STRUCTURAL TESTING
MSFC LARGE SYSTEMS TESTING FACILITIES
MSFC 3/80-AB-400-236A

Figure 3

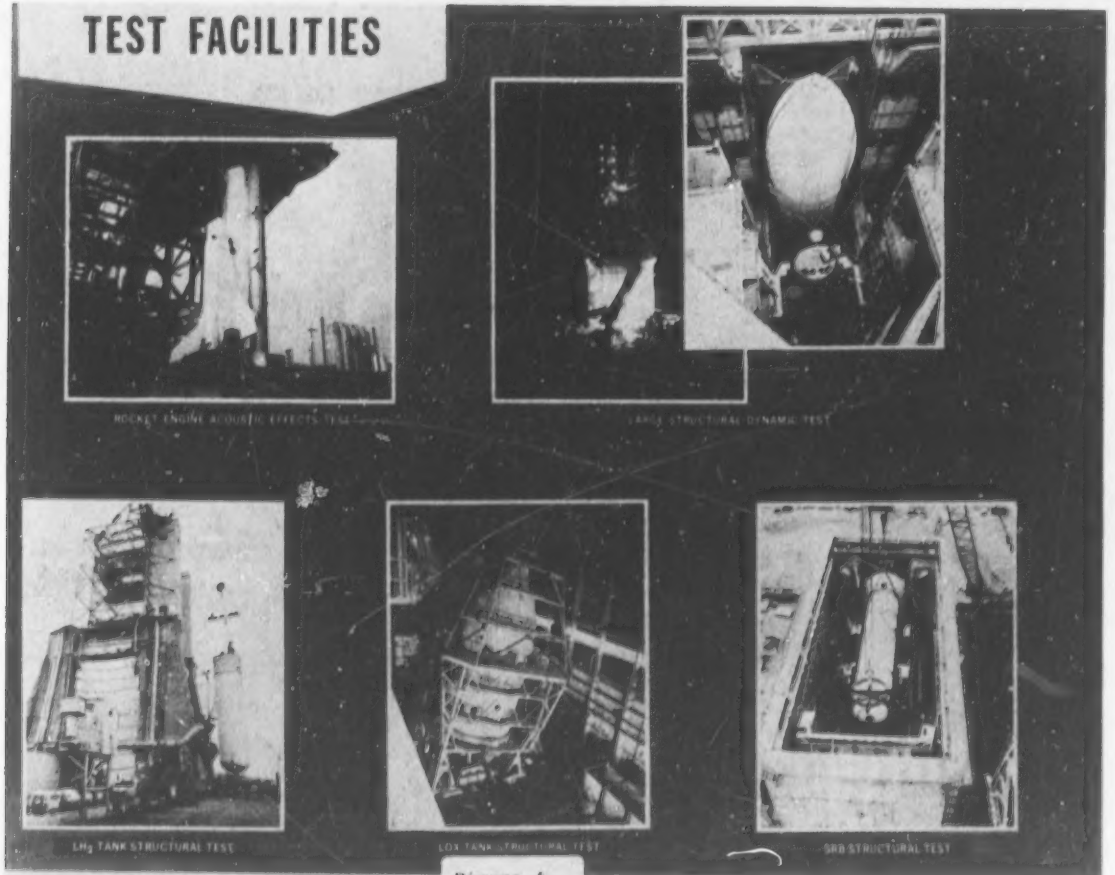

TEST FACILITIES
ROCKET ENGINE ACOUSTIC EFFECTS TEST
LH2 TANK STRUCTURAL TEST
LOX TANK STRUCTURAL TEST
SRB STRUCTURAL TEST

Figure 4

Figure 5

MSFC MAJOR CONTRACT AND RESIDENT OFFICE LOCATIONS

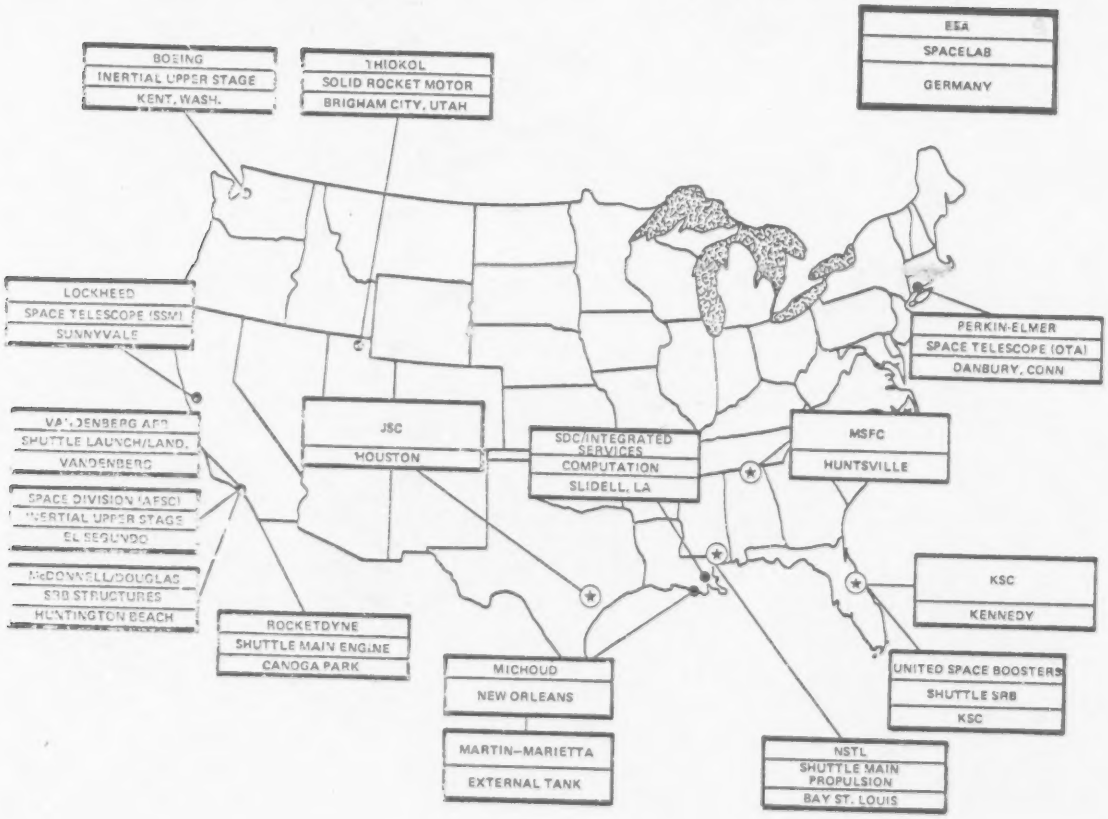


Figure 3

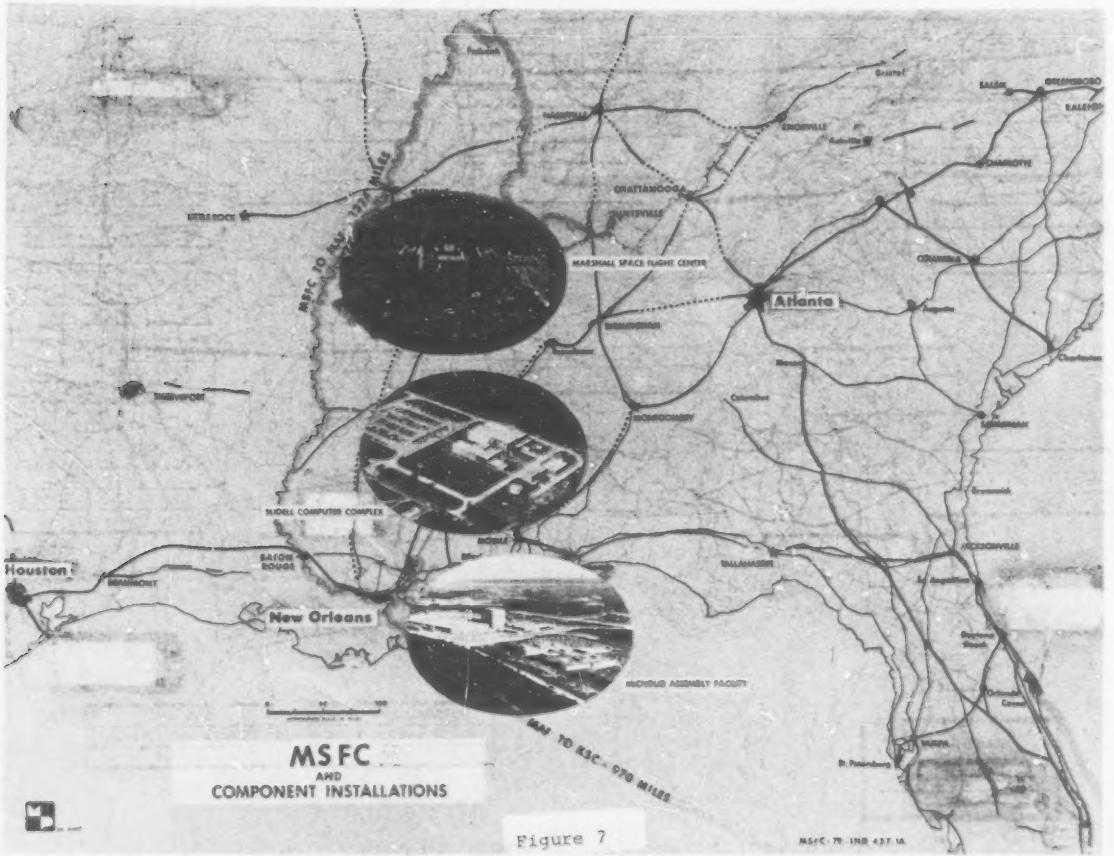

MSFC TO MAF - 1377 MILES
MARSHALL SPACE FLIGHT CENTER
Atlanta
Houston
New Orleans
MICHOUD ASSEMBLY FACILITY
MAF TO KSC - 978 MILES
MSFC
AND
COMPONENT INSTALLATIONS

Figure 7

MICHOUD ASSEMBLY FACILITY

Figure 8

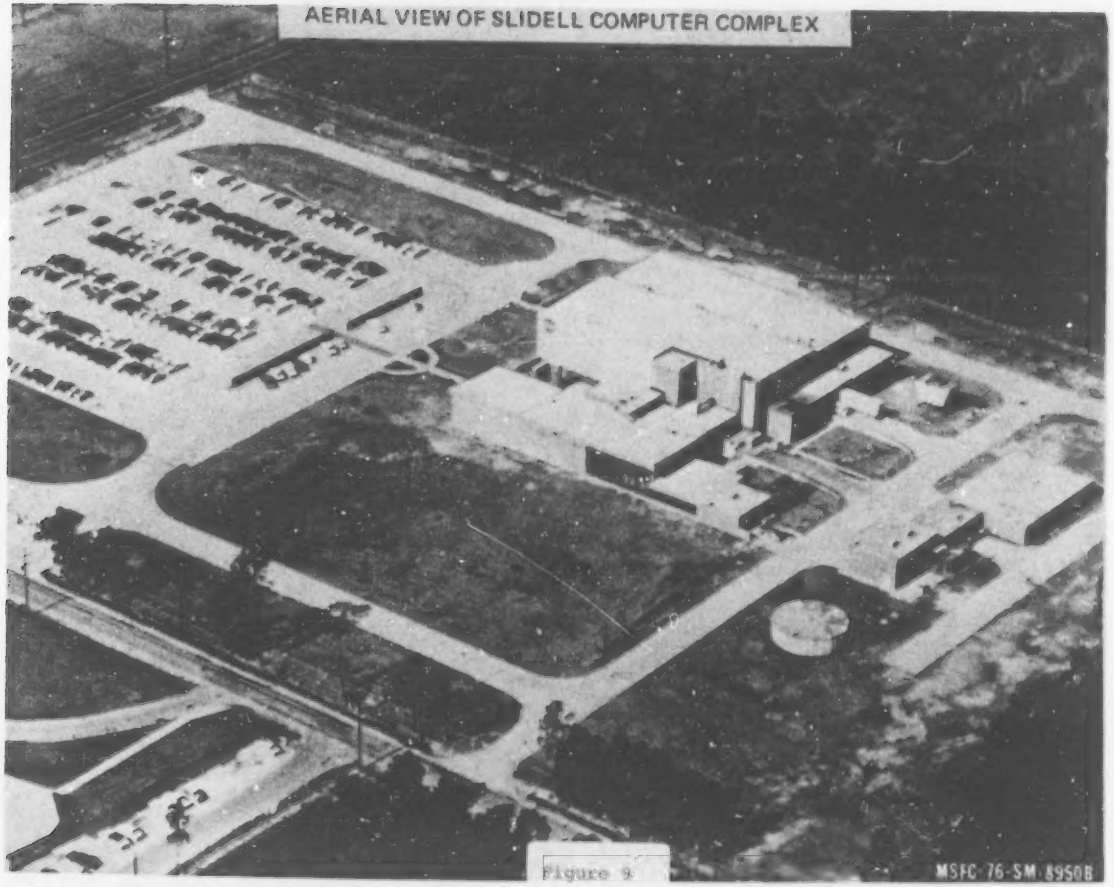


Figure 9

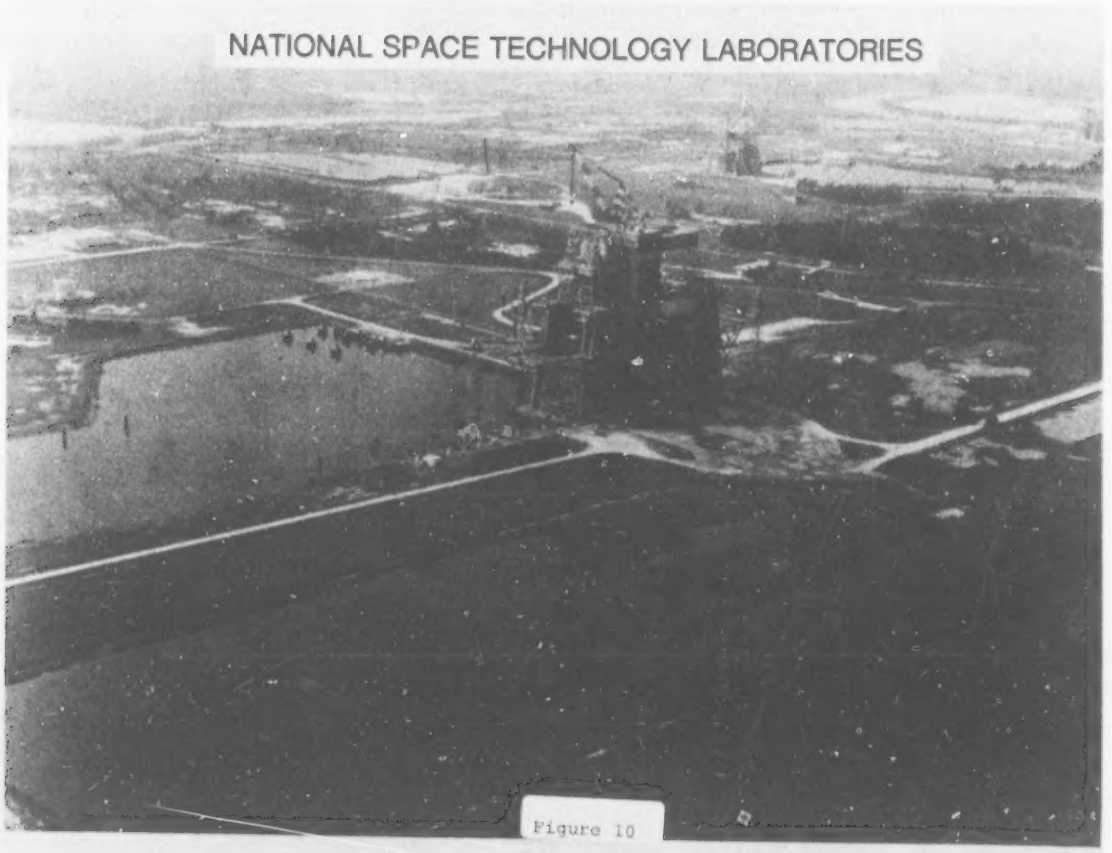


Figure 10

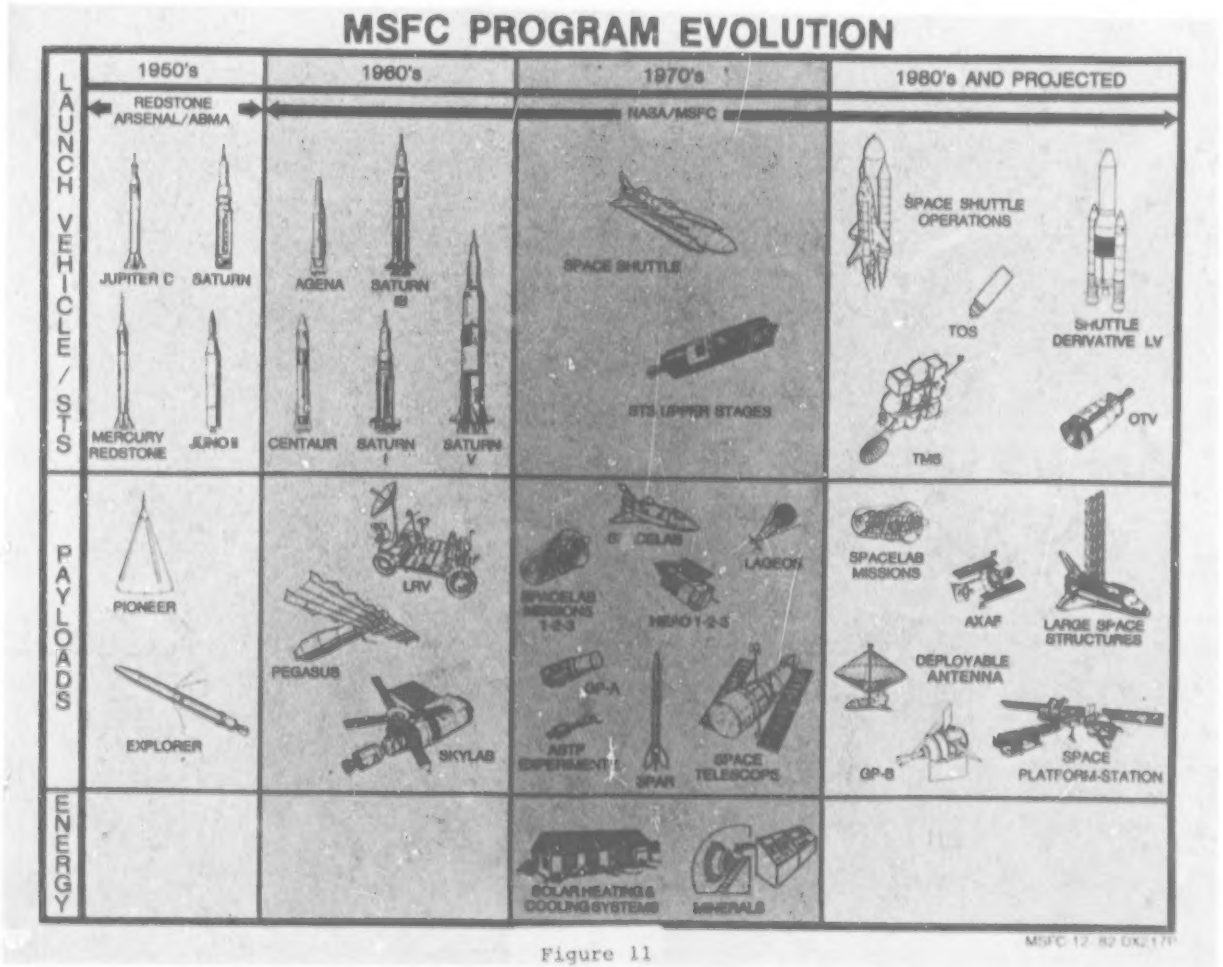

MSFC PROGRAM EVOLUTION
1950's
1960's
1970's
1980's AND PROJECTED
LAUNCH VEHICLE / STS
PAYLOADS
ENERGY
REDSTONE ARSENAL/ABMA
NASA/MSFC
JUPITER C
SATURN
AGENA
SATURN IB
MERCURY REDSTONE
JUNO II
CENTAUR
SATURN I
SATURN V
SPACE SHUTTLE
STS UPPER STAGES
SPACE SHUTTLE OPERATIONS
TOS
SHUTTLE DERIVATIVE LV
TMS
OTV
PIONEER
LRV
PEGASUS
EXPLORER
SKYLAB
SPACELAB MISSIONS 1-2-3
LAGEOS
HEAO 1-2-5
GP-A
SPAR
SPACE TELESCOPES
SPACELAB MISSIONS
AXAF
LARGE SPACE STRUCTURES
DEPLOYABLE ANTENNA
GP-B
SPACE PLATFORM-STATION
SOLAR HEATING & COOLING SYSTEMS
MINERALS

Figure 11

3910 -81

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEORGE C. MARSHALL SPACE FLIGHT CENTER

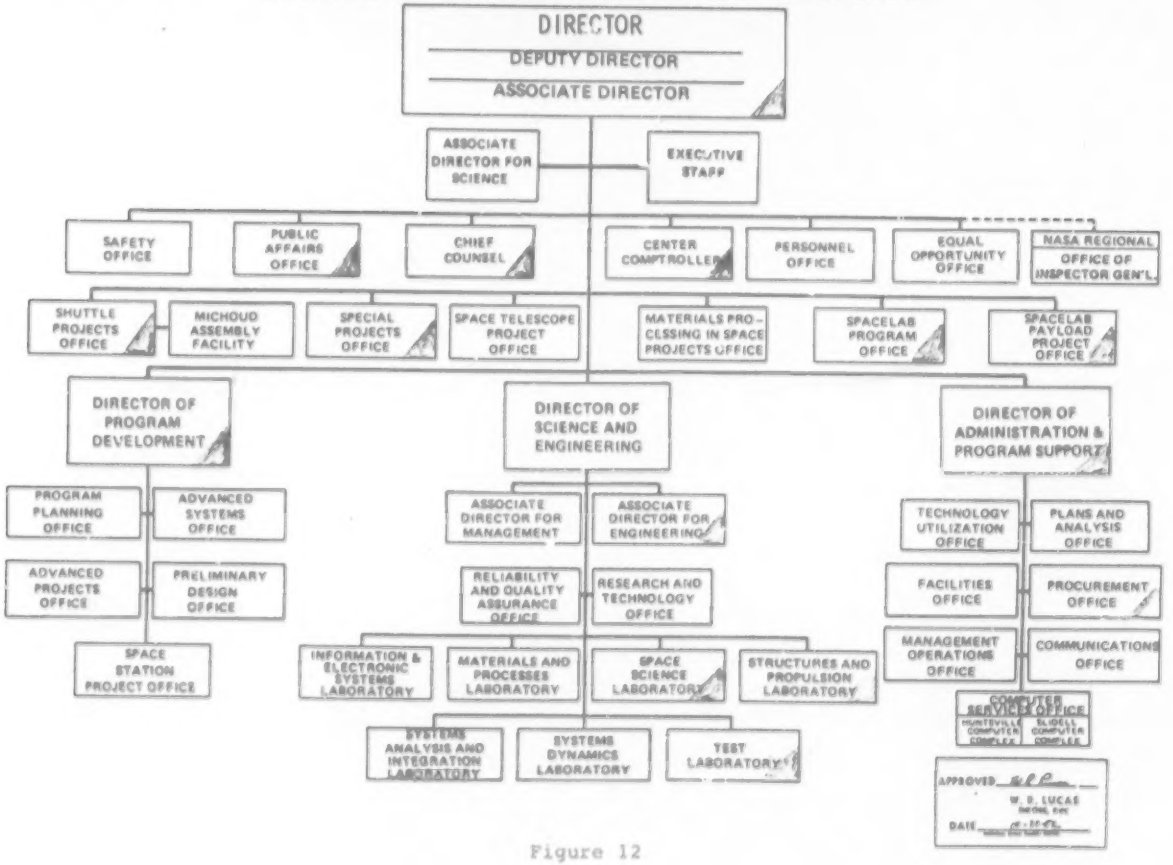


Figure 12

2196-81

MSFC EDUCATION LEVELS

● DEGREE LEVEL	2248
- DOCTORATE	105
- MASTERS	438
- BACCALAUREATE	1705
● NON-DEGREES	1099
- TECHNICIANS	376
- CLERICAL	456
- ADMINISTRATIVE SPECIALIST AND NON-DEGREE ENGINEERS	267

DATA AS OF JANUARY 1983

940

Figure 13

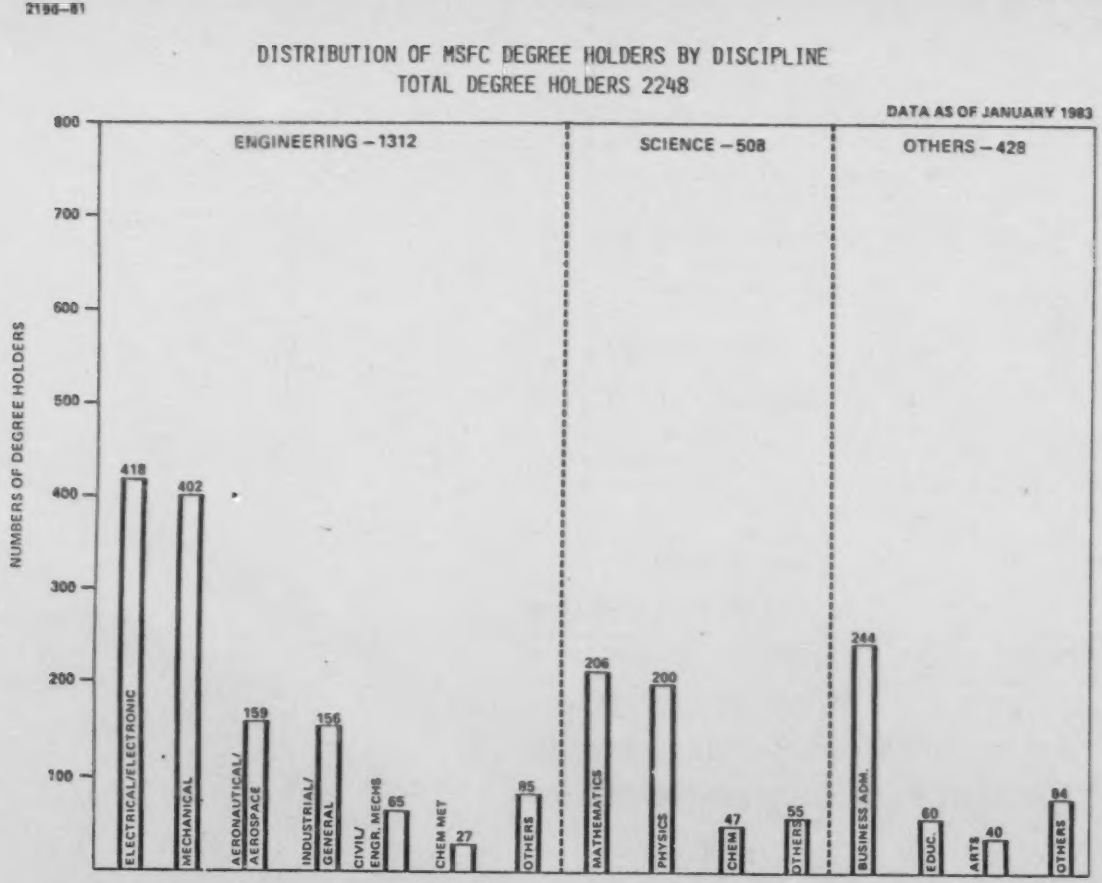


Figure 14

19-006 O—83——60

2195-81

MSFC AREAS OF TECHNICAL EXCELLENCE

- MANAGEMENT OF COMPLEX PROGRAMS
- SYSTEMS ENGINEERING AND INTEGRATION
- SYSTEMS DEVELOPMENT
- PAYLOAD SYSTEMS ANALYSIS AND INTEGRATION
- TECHNICAL DISCIPLINES
  - PROPULSION SYSTEMS
  - STRUCTURAL SYSTEMS
  - MATERIALS SCIENCE AND ENGINEERING
  - ELECTRONICS, GUIDANCE, NAVIGATION AND CONTROL
  - POWER SYSTEMS
  - DATA SYSTEMS
- SCIENCE AND APPLICATIONS AREA
  - SOLAR TERRESTRIAL RELATIONSHIPS
    - SOLAR PHYSICS
    - MAGNETOSPHERIC PHYSICS
    - ATMOSPHERIC PHYSICS
  - ASTRONOMICAL OBSERVATORIES
    - LARGE ASTRONOMICAL OBSERVATORY DEVELOPMENT
    - HIGH ENERGY AND OPTICAL ASTRONOMY
  - RELATIVITY PHYSICS
  - MATERIALS PROCESSING IN SPACE

Figure 15

MSFC PROGRAM/PROJECT ACTIVITY

2/23/83

APPROVED FOR IMPLEMENTATION	ASSIGNED FOR DEFINITION	PROPOSED FOR FUTURE
• SPACE SHUTTLE – MAIN ENGINE – EXTERNAL TANK – SOLID ROCKET BOOSTER – SYSTEMS ANALYSIS, TEST & INTEGRATION	• TRANSFER ORBIT STAGE	• SHUTTLE DERIVED VEHICLES • SPACE STATION
• STS OPERATIONS		• GEOSTATIONARY PLATFORM
• INERTIAL UPPER STAGE		• ORBITAL TRANSFER VEHICLE
• SPACELAB	• TETHERED SATELLITE SYSTEM	• TELEOPERATOR MANEUVERING SYSTEM
• SPACELAB P/L MISSION MGMT	• SPACE PLATFORM	• DEPLOYABLE ANTENNA FLIGHT EXPERIMENT • LARGE SPACE STRUCTURES ENGINEERING
• MATERIALS PROCESSING – EXPERIMENT DEVELOPMENT – PRECURSOR EXPERIMENTS – SPACE SHUTTLE PAYLOADS	• ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)	• SOLAR TERRESTRIAL OBSERVATORY
• SPACE TELESCOPE		• PIN HOLE OCCULTER
• FLIGHT EXPERIMENT	• GRAVITY PROBE B (GP-B)	• ADVANCED SOLAR OBSERVATORY
• SUPPORTING RESEARCH AND TECHNOLOGY		

Figure 16

IUS 2-STAGE TDRS SPACECRAFT

Figure 17

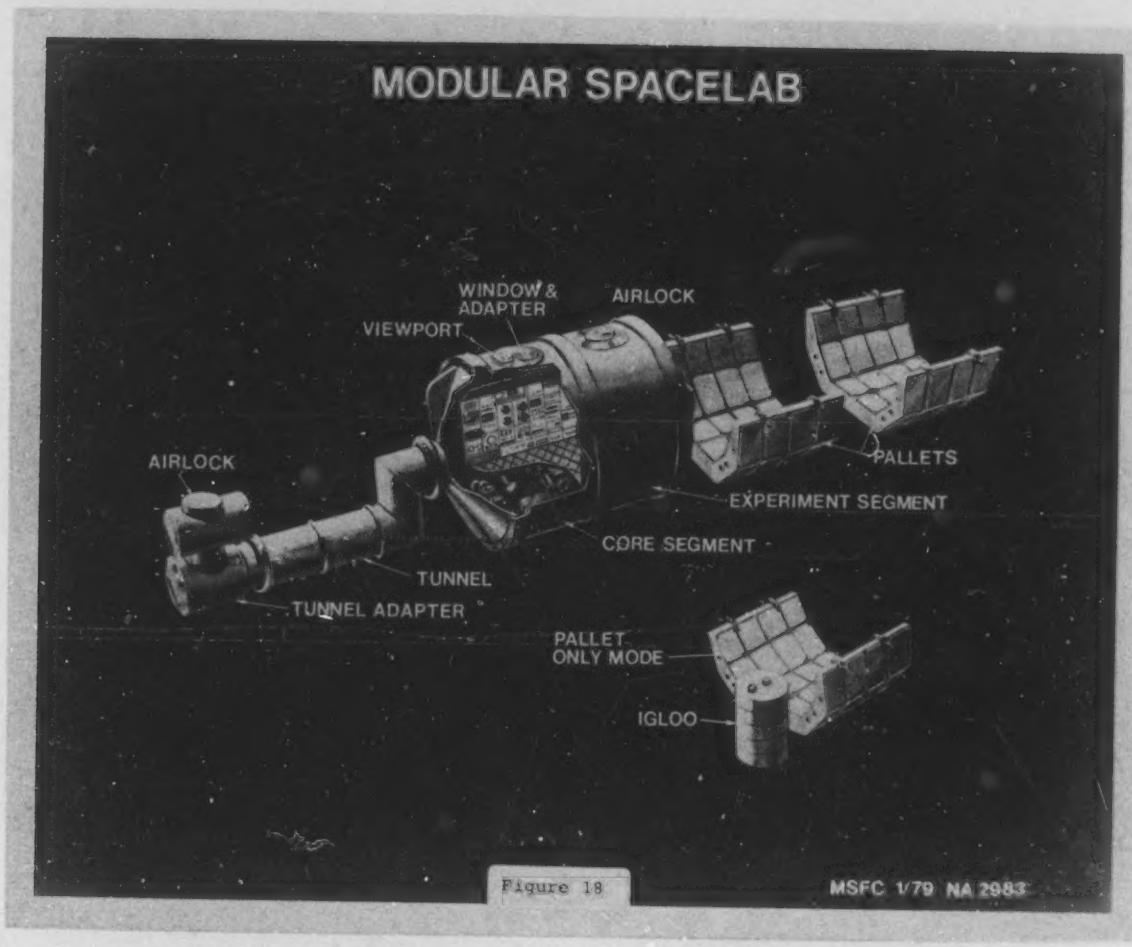

MODULAR SPACELAB
WINDOW & ADAPTER
VIEWPORT
AIRLOCK
AIRLOCK
PALLETS
EXPERIMENT SEGMENT
CORE SEGMENT
TUNNEL
TUNNEL ADAPTER
PALLET ONLY MODE
IGLOO
MSFC 1/79 NA 2983

Figure 18

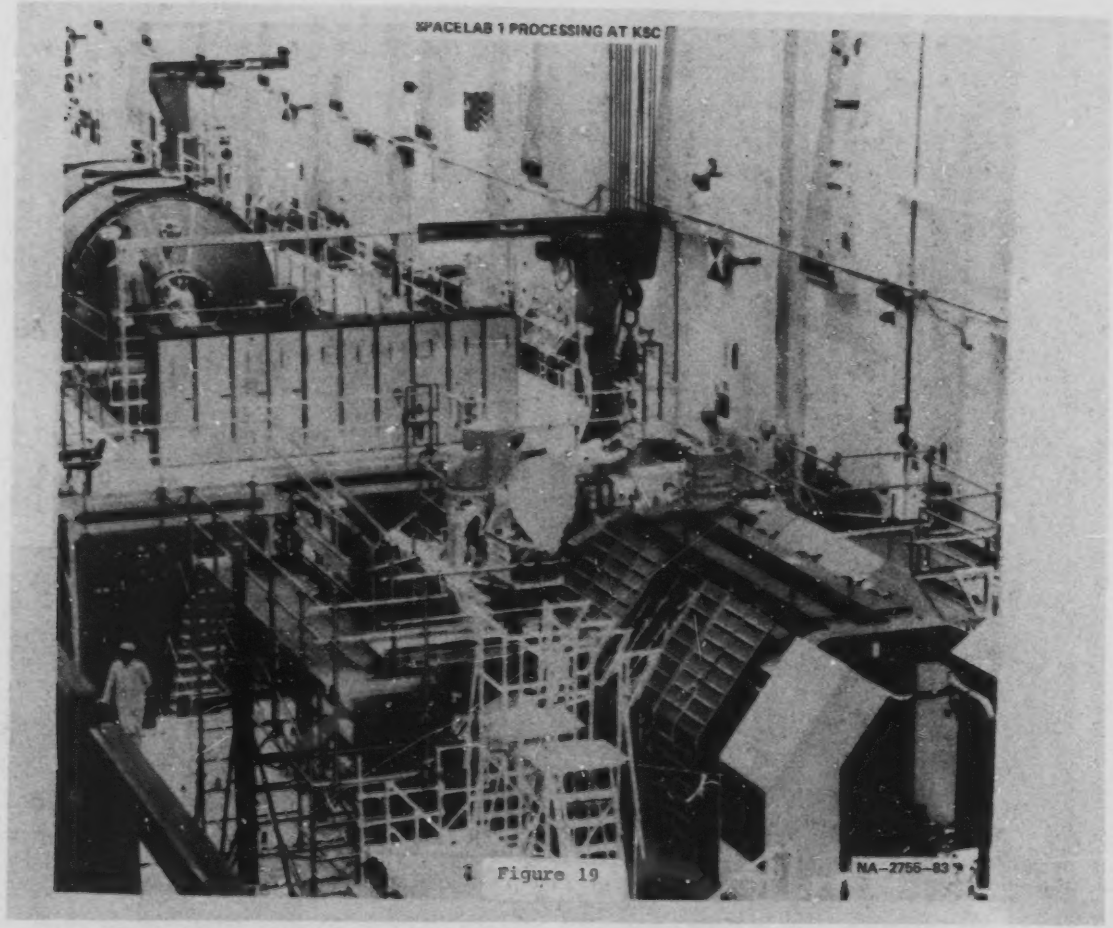
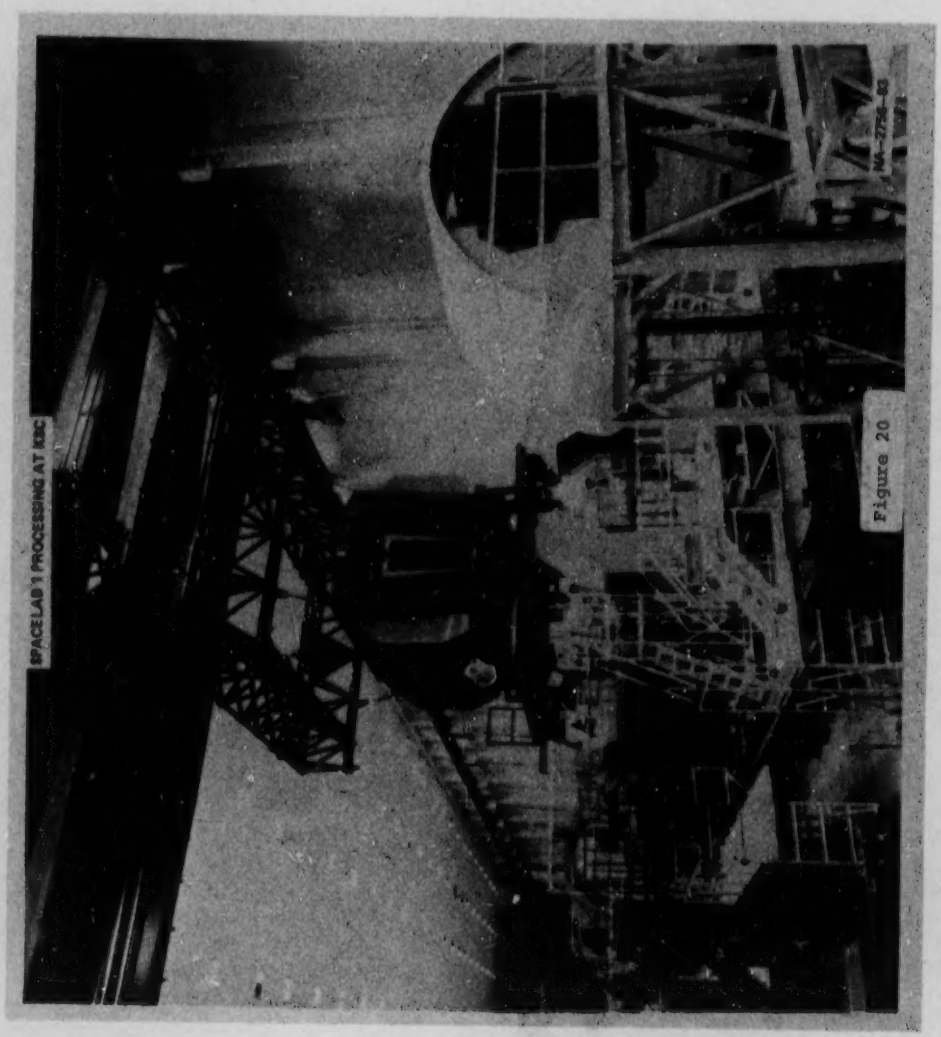


Figure 19


SPACELAB 1 PROCESSING AT KSC
Figure 20

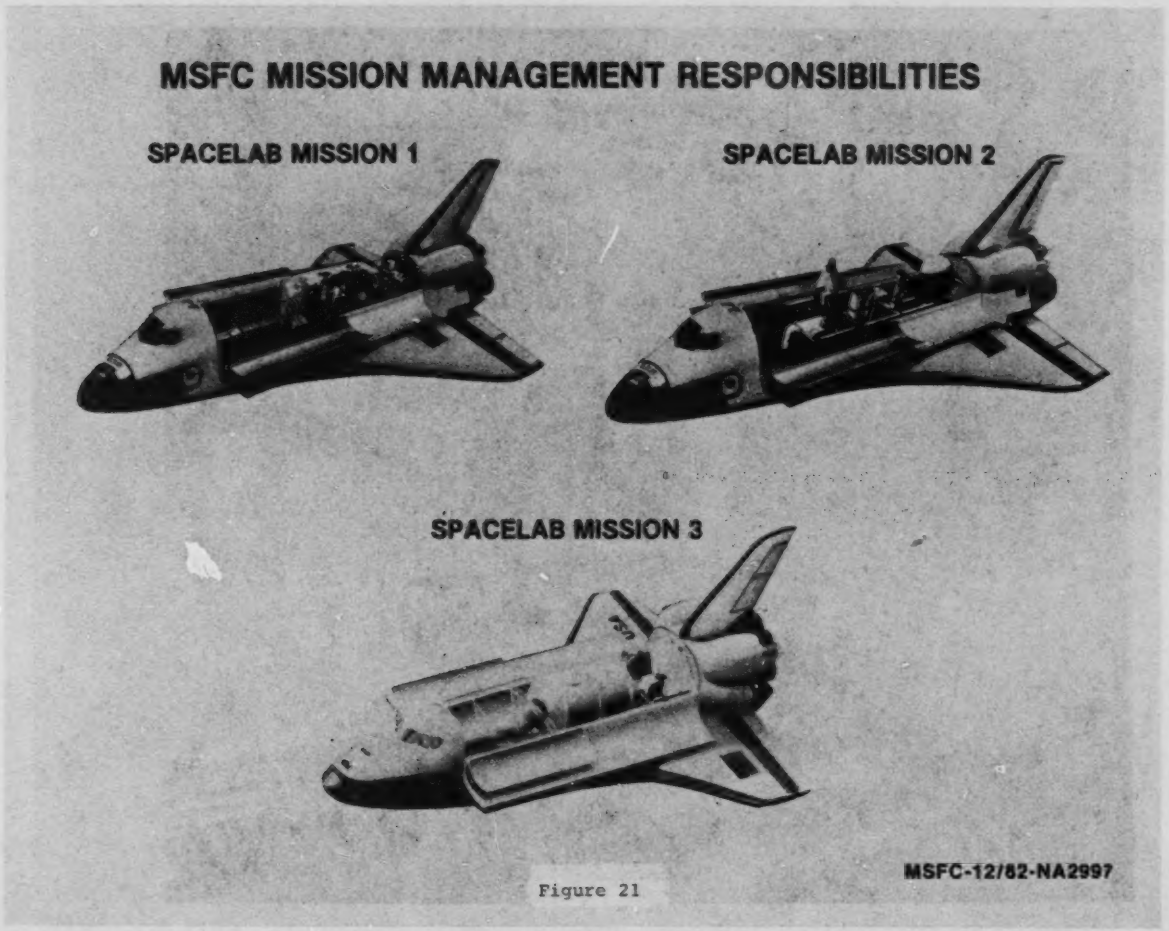

MSFC MISSION MANAGEMENT RESPONSIBILITIES
SPACELAB MISSION 1
SPACELAB MISSION 2
SPACELAB MISSION 3
MSFC-12/82-NA2997

Figure 21

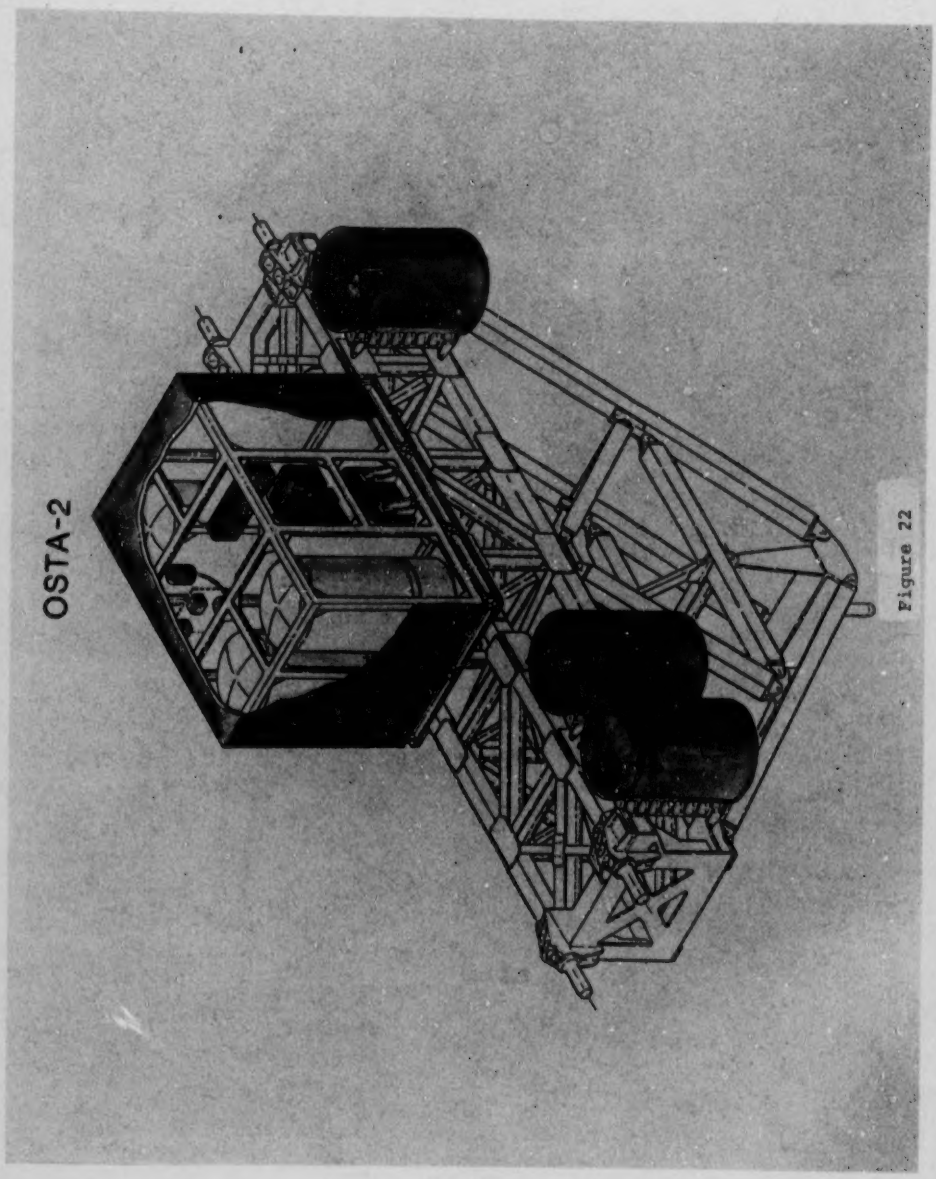


Figure 22

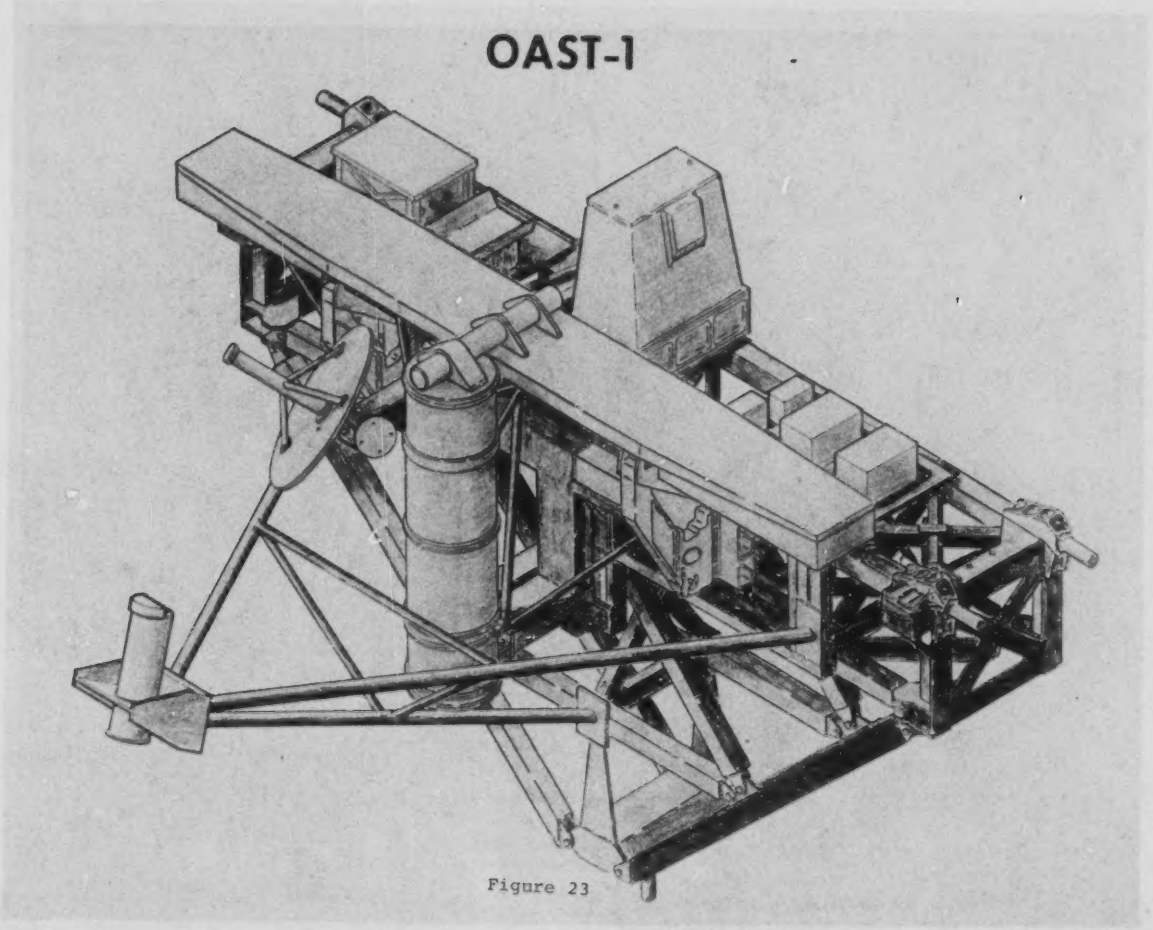


Figure 23

Figure 24

0766-83

MATERIALS PROCESSING IN SPACE

THE MATERIALS PROCESSING IN SPACE (MPS) PROGRAM UTILIZES THE UNIQUE LOW-GRAVITY ENVIRONMENT OF SPACE FLIGHT TO PROVIDE:

- FUNDAMENTAL KNOWLEDGE OF GRAVITY EFFECTS IN MATERIALS PROCESSES
- DEMONSTRATION OF MATERIALS THAT CAN BE PRODUCED ONLY IN SPACE
- IDENTIFICATION OF COMMERCIAL OPPORTUNITIES FOR PROCESSING IN SPACE

Figure 25

TRANSCRIPT OF TESTIMONY

by

ROBERT E. LINDSTROM
MANAGER, SHUTTLE PROJECTS OFFICE

MR. LINDSTROM: Mr. Chairman, Representative Lujan, and Representative Flippo, I will be supplementing my prepared statement with the following series of charts. Figure 1 reflects the agenda I will be discussing today. The Center's role in the Space Shuttle program involves four major areas: Solid Rocket Booster, Space Shuttle Main Engine, External Tank, and the Systems activities. As part of the engine briefing, I have included data regarding the current problems we have been experiencing with the Challenger engines. Since you have already visited Michoud, and received a detailed briefing I will only highlight selected areas in the External Tank portion.

At this time, I would like to take the opportunity to mention several organizational changes I have made within the Shuttle Projects Office.

Within the Shuttle program, there is a continuing development and sustaining engineering role principally on the Engine and Solid Rocket Boosters. Concurrently, we are increasing our production and logistics effort to support the flight program. In order to provide more emphasis to these two areas, I have established two Deputy positions within my office. Mr. George Hardy, Deputy for Development Engineering, who was previously Manager of the Solid Rocket Booster Project; and Mr. James Odom, Deputy for Production/Logistics, who attended the field hearings with you at Michoud. In March of 1982, Dr. Judson Lovingood became Manager of the Space Shuttle Main Engine. Mr. Porter Bridwell has recently replaced Mr. Jim Odom as Manager of the External Tank Project. Mr. Larry Mulloy has assumed the role of Manager of the Solid Rocket Booster and he will be on tour with you this afternoon.

I have categorized the Center's role into two major phases of activity, as listed on Figure 2, the DDT&E phase and the Support to Operations phase. Figure 3 is a depiction of our responsibilities. In DDT&E, we have completed the development certification of the External Tank, Solid Rocket Booster and the Main Engine. We are also responsible for propulsion testing at the National Space Technological Laboratories (NSTL) in Mississippi. The Center is very active in the propulsion and ascent flight systems integration - how the total vehicle systems, including the Orbiter, Tank, Engine, and Solid Rocket Booster, perform during the boost phase of the program, and up through the point of separation from the External Tank. As indicated in Dr. Lucas' briefing, we have significant experience in the boost phase technology. We participate jointly with Johnson Center in this role. Also,

you will note throughout my briefing, that there are a number of performance improvements being made to our elements which add to the payload capability of the Space Shuttle. For example, during your visit to Michoud, you were briefed on the accomplishments of the lightweight tank program. In support to operations, our major role is in production and logistics support of the elements: External Tank, Solid Rocket Booster and Main Engine. We provide launch support to the Kennedy Space Center (KSC) and to Vandenberg Air Force Base (VAFB) in terms of technical data on our elements, problem resolution and sustaining engineering. We are also involved in the activation of the Vandenberg facility. Throughout the program, we are making a number of operational improvements in terms of producibility and lower costs. We are doing a formal review of requirements with the intent to reduce the requirements and lower the costs. We are also involved in efforts to simplify launch processing in terms of reducing the requirements of the work to be done at Kennedy and improve the turnaround of the vehicle.

In conjunction with each project, I will follow this general outline as shown on Figure 4. I will discuss the respective hardware characteristics, summarize the project in terms of its development history, list accomplishments during the last year and major activities forecasted for 1983. I then will take just a moment to discuss the key project emphases each Project will be working during the next few years. The Solid Rocket Booster (SRB) element is comprised of two major entities: the solid rocket motor and booster subsystems as illustrated on Figure 5. The solid rocket motor is developed and produced by the Morton-Thiokol Corporation. It consists of four segments and a nozzle. The total booster consists of the motor and the aft and forward assemblies.

The Thrust Vector Control (TVC) system is located in the aft assembly and the recovery system within the forward assembly. As I mentioned Morton-Thiokol is responsible for the development, fabrication and production of the motors (Figure 6). United Space Boosters, Inc. (USBI) is responsible for the booster assembly - assembly of elements: aft and forward assembly. MSFC is currently transferring to USBI the booster subsystem engineering responsibilities which was previously handled by our civil service personnel. A number of subcontractors: McDonnell Douglas, Martin Marietta, MOOG, and Bendix are also involved in SRB development. Testing of the motor is done at Morton-Thiokol, and as Dr. Lucas indicated, the structural testing of the booster was accomplished at Marshall.

The SRB program started in 1973 (Figure 7). The program was initially begun as an in-house design development. Contracturally we started the motor first, in late 1974, with the Thiokol Corporation. The first motor firing was in 1978 with qualification completed in 1980. In 1979, we began work on a lightweight case to improve performance and this lighter weight case will be flown on STS-6. In 1981, we started development of a high performance motor (HPM). The first HPM was successfully tested in October 1982 and the second and final HPM test will be held in mid-March. The HPM will be used on STS-8. Figure 8 is a picture of the first HPM firing in October 1982. The objective of the high performance motor is to yield an increase in payload capability by approximately 3,000 pounds. We also started studies in 1981 for system improvements to further increase the performance and we are anticipating an increase in the region of 5,000 to 6,000 pounds. A decision was made in May 1982 to proceed with the Filament Wound Case. This is under contract to

MPS PROGRAM ELEMENTS

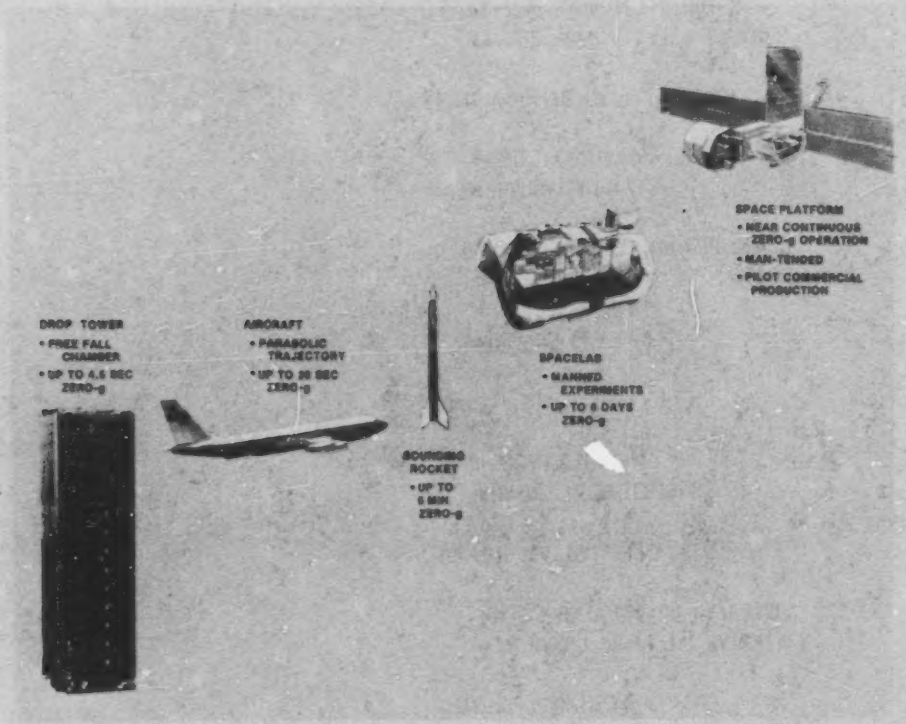


Figure 26

0762-83

AREAS OF RESEARCH

CRYSTAL GROWTH PROCESSES

- INFRARED DETECTOR MATERIALS
- NUCLEAR DETECTOR MATERIALS

SOLIDIFICATION PROCESSES

- MAGNETIC MATERIALS
- COMPOSITES

CONTAINERLESS PROCESSES

- UNIQUE GLASSES
- OPTICAL FIBERS

BIOLOGICAL SEPARATION PROCESSES

- PHARMACEUTICALS
- CELL SEPARATION

FLUID AND CHEMICAL PROCESSES

- MONODISPERSE LATEX SPHERES
- FLUID DYNAMICS STUDIES

Figure 27

0731-83

MATERIALS PROCESSING IN SPACE
JOINT ENDEAVOR AGREEMENTS (JEA'S)

COMPANY	AREA OF INTEREST	STATUS
McDONNELL-DOUGLAS ASTRONAUTICS COMPANY	CONTINUOUS FLOW ELECTROPHORESIS	APPROVED JAN. 25, 1980
MICROGRAVITY RESEARCH ASSOCIATES	CRYSTAL GROWTH IN LOW GRAVITY	IN REVIEW PROCESS

FEBRUARY 1983

Figure 28

0734-83

MSFC EXPERIMENTS ON STS FLIGHTS 2 THROUGH 9

- INDUCED ENVIRONMENT CONTAMINATION MONITOR (IECM)
- NIGHTTIME-DAYTIME OPTICAL SURVEY OF LIGHTNING (NOSL)
- ENGINEERING MODEL OF SPACELAB PALLET
- MONODISPERSE LATEX REACTOR (MLR)
- ELECTROPHORESIS ENGINEERING VERIFICATION TEST
- RETARDING POTENTIAL ANALYZER/DIFFERENTIAL ION FLUX PROBE
- CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES)
- MATERIALS EXPERIMENT ASSEMBLY (MEA)
- SPACE EXPERIMENTS WITH PARTICLE ACCELERATOR (SEPAC)
- ATMOSPHERIC EMISSION PHOTOMETRIC IMAGER (AEPI)
- TRIBOLOGY EXPERIMENT
- VERIFICATION FLIGHT INSTRUMENTATION

FEBRUARY 1983

Figure 29

SUPPORTING RESEARCH AND TECHNOLOGY

- MAJOR THRUST
  - CHEMICAL PROPULSION
  - LARGE SPACE STRUCTURES
  - INFORMATION & ELECTRONIC SYSTEMS
  - ELECTRIC POWER SYSTEMS
  - PHYSICAL & ASTRONOMICAL SCIENCES
  - SPACE MATERIALS PROCESSING
- PUBLICATIONS AND PRESENTATIONS ON ADVANCEMENTS
  - OVER 230 PUBLICATIONS AND PRESENTATIONS
  - EIGHTY NINE ARTICLES PUBLISHED IN ARCHIVE JOURNALS
- PATENTS

  ELEVEN PATENTS AWARDED

Figure 30

JANUARY 1983

19-605 O—83——61

Morton-Thiokol with a joint venture by Hercules, Inc. and Votaw Precision Tool as the case subcontractors. The first full scale filament wound case will be produced in the Spring of this year and the first test firing of a motor with this configuration is planned in the Spring of 1984. We plan delivery of motors with filament wound cases in the Spring of 1985 for the first launch from Vandenburg in October 1985. I would like to take just a moment to describe the filament wound case and the differences between the all-steel case and a filament wound case (Figure 9). A steel case is made of eleven steel segments which we make into four casting segments. On the filament wound case, we have replaced the cylindrical steel segments with a filament wound material. We have retained the steel forward and aft domes as we are now using in the current motors. Also, the segment which provides the attach points to the External Tank is retained as steel. As I indicated, a payload increase of about 5,500 pounds is anticipated with this change. Figure 10 is a picture of the 1/4 scale case being wound with the helical layer at Hercules. The Hercules Company has done a great deal of filament wound wrapping over the years. Figure 11 is a view of the first full-scale segment on the mandrel showing the laying up of broadgoods.

MR. LUJAN: What is the diameter on that Solid Rocket Booster?

MR. LINDSTROM: 146 inches

The Solid Rocket Booster accomplishments for the last year are categorized into two phases (Figure 12). In DDT&E, we completed the successful launch of the first three boosters; however, we did have some problems on STS-4 with the loss of the boosters during recovery. We incorporated a fix on STS-5

which resulted in the successful recovery of the boosters. All of the boosters performed flawlessly in the ascent phase to provide the initial thrust for the first two minutes. I'm sure you are aware that we have experienced more damage to the booster during water entry than expected, this was caused by some thermal damage during the re-entry and also the water impact. We have continued to make design modifications and repairs and are achieving some success in this area. I have already discussed the performance enhancements we have accomplished.

In support of operations, we have completed the successful launch and recovery of STS-5 (Figure 13). I would like to show you a few pictures of the Solid Rocket Booster recovery. Figure 14 shows the STS-5 Booster at splashdown. The chutes are in the water and the recovery ships will soon be moving in for pick-up. Figure 15 shows the UTC Liberty towing the booster into Port Canaveral. I believe the Solid Rocket Booster is the largest item that has ever been recovered with a parachute. Figure 16 shows the disassembly facility at Port Canaveral. During this phase, the boosters are brought into the slip, raised with cranes and disassembly and washdown begins.

Figure 17 shows a frustum from STS-5. The damage on the frustum and the forward unit has been very minimal. Most of the material on the structure can be used readily without any repair. As a result of firing the separation rockets, you will note some scorching on the TPS and some damage to the paint surface. As we move further into operations, we expect to be able to reduce the amount of insulation on this vehicle. We are just exploring the flight regime and once we get good flight data and re-do our calculations; we

should be able to reduce insulation which, in turn, will reduce cost and turnaround time. Most of our damage requiring repair is in the aft skirt. Figure 18 shows the aft skirt of the Solid Rocket Motor. There is a nozzle extension (not shown) which we separate prior to entering the water and a thermal curtain located in this area. The loss of this thermal curtain is causing some thermal damage inside the aft skirt. Also, we have experienced some structural damage to the aft skirt because of the water impact loads. We made some fixes on STS-5 and reduced substantially the amount of damage.

Looking back for a moment at the accomplishments listed on Figure 13, we have currently delivered STS-6 and STS-7 hardware, the motors as well as the boosters, to the Kennedy Space Center. I would like to address several other significant accomplishments. A formal Requirements Reduction Review has been implemented. The initial step has been completed and we are beginning to reduce the requirements on the vehicle. We expect the trend to continue to reduce the stacking time and the time the vehicle is in the VAB. This effort is planned for completion between vehicle flight 17 and flight 26.

We have also changed our contracting mode. The development contracts were all cost plus award fee (CPAF). As we move into production, we are negotiating a cost plus incentive fee (CPIF) arrangement. We have negotiated a cost plus incentive fee contract with Morton-Thiokol for the production of the motors. Also, we have reviewed several facility options for location of a Solid Rocket Booster refurbishment and assembly facility.

In regard to capability development (Figure 19), I mentioned that in 1983, we will continue to complete hardware design and redesign to reduce the water impact. The major activity, however, will be the development of the SRM filament wound case. The structural testing of that case will be conducted in a Marshall test facility, as Dr. Lucas mentioned. As I stated before, the last firing of the high performance motor will be in mid-March.

Our operational and production/logistics activities have steadily intensified during this year with the increased production rate. It will take a great deal of emphasis by ourselves and by our contractors. We expect to contract with Morton-Thiokol for another block of motors for flight 16 through flight 32, again, on a CPIF basis. We are also considering fixed price incentive fee contracting; however, it will not be on this block but may occur on the next block.

Figure 20 summarizes some of the things I have just said in terms of the emphases. I portray this to you primarily so you can understand what resources are required at the Center and what resources it takes from the contractor. Performance is still dependent upon the completion of the recovery and reuse assessment which requires some engineering activity from the Center as well as from our contractors. We are accelerating tooling, facilities and production readiness to establish a production rate capability. I might mention that this was one of the first programs that NASA moved into a high rate of production. We looked at what the Department of Defense had done to achieve production readiness and we subsequently established a formal production readiness review to assess the capability to produce. These reviews

have been conducted in the last few years in much the same manner as a flight readiness review. These reviews will continue until the production capabilities are achieved. From the standpoint of cost reduction, a great deal of emphasis is based on requirements, producibility and incentive contracting. There is a continuing effort in sustaining engineering both at the Center and with our contractors, as I have indicated, especially in the SRB project. Improvements made in terms of the closeouts in the VAB will shorten turnarounds. That completes my discussion on Solid Rocket Booster. Do you have any questions, sir, on the booster?

CHAIRMAN VOLKMER: No, not at this time, I will probably have some later.

MR. LINDSTROM: I will now cover the Main Engine, (Figure 21). I will also include a discussion on the Challenger engine status, the crack in the main combustion chamber and engine 2016. Dr. Lovingood will then update you on the latest status.

Since you visited the National Space Technology Laboratories (NSTL) Saturday afternoon, I won't reiterate the characterisitics of the main engine (Figure 22). The prime contractor is Rocketdyne with two major subcontractors: Honeywell, Inc. responsible for the controller, and Hydraulic Research which builds the actuators for the valve controls on the engine. Test facilities are located at the NSTL, and Santa Susana, a field laboratory. As you will recall from your visit, two stands for SSME testing at NSTL are operated by MSFC. In addition, the Marshall Center operates the Main Propulsion Test (MPT) stand under an agreement with NSTL.

The Engine program was started in 1972 (Figure 24). Contractually, period A - development, was from go-ahead through Critical Design Review (CDR). The first engine test was at NSTL on an Integrated Systems Test Bed (ISTB), a breadboard type engine. Three engines were manufactured in mid-1975 and CDR occurred in 1976. We then contracted period B, which is the development and production phase. During period B, seven development and seven production engines were manufactured. We split the certification development of this engine into two phases. We concentrated initially in 1978, 1979, and 1980 on the 100% rated power level (RPL) engine and completed certification of the first cycle in 1979 and the second cycle in 1981. These are the engines that were flown on Columbia. We are currently in the certification process for the full power level (FPL) on 109% engine. This first cycle was completed in early 1982 and the fourth cycle should be completed in the near future. This certification is being accomplished at 109%. Two of the engines we delivered for Challenger were certified and acceptance tested at 109%. However, for the near term period, the 104% level will be used to power Challenger. In 1977, we purchased some additional engines. The initial buy was through production engine 16 with incremental additions as the program evolved. We are currently under contract through engine 2026. So, we have had 10 development engines and 26 flight engines. The other activities that will support the program are flight support and overhaul. We expect to complete overhaul of the first Challenger engine and spare Challenger engine in August of this year. The first flight set from Columbia will be overhauled and modified to operate at 109% capability in 1984. Certification confirms the engine capability for ten flights and thus, there will be a continuing program to certify the engine for additional flights in

increments of ten. This certification will involve testing, perhaps some modification, the development of maintenance plans and determining when components need to be changed out. As demonstrated, the Columbia flight engine experience was outstanding (Figure 25). All flights were successful, with no flight problems. The inspection maintenance capability was demonstrated. We conduct our certification identical to the flight. In other words, we test under the same conditions, same redlines and in between tests we perform the same inspection and maintenance as we do between flights in order to prove those processes and demonstrate the reuseability. We now have a total of 172,000 total seconds on the engine. Figure 26 shows several key points. The cross hatch area indicates the testing we have achieved in the last year and as reflected most of our testing has been at 109% or full thrust level totaling about 18,000 seconds. So we are continuing to operate the engine at the higher thrust level. The black area indicates the amount of test time on the engines at 100% both in the main propulsion test program and the flight program. We have done some 100% testing the last year but the primary focus has been at the full power level, or 109%. We have experienced some problems in FPL testing which has been centered around the high pressure pumps (Figure 25). On the high pressure fuel pump, we have had problems associated with the operating temperature of the turbine exhaust and efforts are being made to lower this temperature. On the oxidizer pump, the problem is centered around the wear on the bearings, spalling on the bearing and bearing cases. At the over stress level (111%), we are detecting some cases of subsynchronous whirl in the pump and are working toward resolution of this problem. Neither of these problems are significant when operating at the 104% thrust level. However, to operate at a 109% level, we would like to have

improvements in both these areas; a reduction in temperature and some margin on the subsynchronous whirl. We currently have modifications in test to resolve these areas of concern.

REPRESENTATIVE LUJAN: Did you say at 109%? It seems like you are asking an engine to do more than the design, but naturally you have made some modifications.

MR. LINDSTROM: That is essentially true. The engines basic design, development and predicted operating level was initially at a 100% thrust level. The 109% level was considered as an emergency power level in 1975 or 1976. I believe it was referred to as an Emergency Power Level (EPL). We had to design for that requirement but concentration was still geared toward the 100% level. As the mission requirements have matured and the systems requirements have changed on the vehicle, our normal operations goal has shifted to the 109% engine. This requirements increase in performance parallels the tank's reduced weight and the Solid Rocket Booster's increased performance.

Our certification program is proceeding with engines 2010 and 2014 (Figure 27). We have completed two cycles on engine 2010 and one cycle on 2014. Figure 28 represents a summary of the certification program listing the certification objectives, certification cycle requirements, and the status of the two engines. I would like to expand on what constitutes a certification cycle. The requirement is for 13 total tests and 13 starts to a rated power level, or at 100%, which is the way we normally start the engine. It requires a minimum duration of 5000 seconds. 3000 seconds must be at the 109% thrust

level and 380 seconds must be at the over stress level, or 111% thrust. In these 13 tests, we must include 8 mission durations, 6 of these would be the nominal mission durations of 500 seconds, and two abort missions: abort to orbit at 595 seconds, and return to launch (RTL) site abort at 750 seconds. The certification cycles have been completed on engine 2010 and one certification cycle has been completed on engine 2014. We have four tests remaining to complete certification of engine 2014.

MR. BRANSCOME: Are these the same cycles that you used for the certification and rated power levels?

MR. LINDSTROM: Yes, they are the same cycles. The FPL certification program is identical to RPL, the only difference is FPL at 109% and 111% for the over stress test.

We have delivered a flight set (Figure 27) and, as you are well aware, have encountered some problems. As a result of the Flight Readiness Firing (FRF) in December, we detected a high concentration of hydrogen in the aft compartment. However, indications are that this amount of hydrogen would not have impeded a safe flight. We repeated the FRF test and discovered a leak in engine no. 1. That engine was replaced, and subsequently, on the replacement engine, a gaseous oxygen leak was discovered in the oxygen heat exchanger. An investigation is in progress. I will discuss the engine 2011 main combustion chamber manifold crack (Figure 29).

CHAIRMAN VOLKMER: We saw that at NSTL.

MR. LINDSTROM: The main combustion chamber (MCC) is a part of the SSME powerhead (Figure 30). A crack occurred in an outlet on the upper manifold. We flow hydrogen into the lower manifold, cooling the MCC wall and then it exits the upper manifold in an outlet to other areas on the engine. Figure 31 is a picture of the MCC. It consists of the inlet, the lower manifold, combustion chamber, and the upper manifold. The crack occurred where the outlet to the upper manifold is welded (Figure 32). Normally, this is welded into the manifold separately. However, when we repaired this particular chamber, the weld was accomplished while the manifold was assembled to the chamber. Figure 33 shows the crack that occurred in the weld of the repaired part. This main combustion chamber was first made and approved in October of 1981 (Figure 34). In the final machining operations, the operator made an error and the outlet elbow struck a machine tool which damaged the elbow. It was then necessary to remove the discharge elbow and replace it with a new elbow that had been made for a subsequent engine. It was replaced in a one-of-a-kind repair and proof tested in April of this year. Subsequently, the engine was tested in engine hot fire acceptance tests and two FRF's. The engine was run for eight tests and accumulated 850 seconds of firing time prior to the time it was removed. Figure 35 represents the manifold as it is normally manufactured. It is an assembly with a manifold and an outlet welded in. The total assembly is then heat treated and the stress caused by this weld is relieved. In the repair, this outlet was welded while assembled to the main combustion chamber making it impossible to heat treat (Figure 36). This repair produced some overheating causing three detrimental effects. There is a copper protective coating inside the manifold which protects the 718 material from hydrogen. The overheating caused a tear because of over stress.

The heat effected zone was extended, reducing the strength capability of the inconel 718. Also, residual stresses were left in the Inconel 718 because we could not stress relieve it. Proof testing did not generate sufficient stress to crack the inconel 718. After we exposed it to acceptance testing at NSTL, hydrogen was able to get through the copper tear and attack the 718, causing hydrogen embrittlement. High residual stresses plus operating stresses are at crack initiation level for Inconel 718 in hydrogen. All the other MCC's on Challenger engines have been determined to be satisfactory because they were fabricated in the standard manufacturing method (Figure 37). The manifold and outlet were assembled as a subassembly and heat treated. We have accumulated 982 tests totaling 170,000 seconds with no cracks or defects in this area. The x-rays of all the welds have been reviewed and are satisfactory. The internal surfaces have been borescoped and determined that the copper is in good condition. An analysis of all the Material Reviews (MR's) will be conducted. When completed, this analysis will clear the Challenger.

I now will discuss the heat exchanger leak (Figure 38). The heat exchanger is an integral part of the SSME powerhead (Figure 39). The heat exchanger is a series of coils in the exhaust or discharge of the high pressure oxygen pump turbine. Its function is to take liquid oxygen, heat it, expand it, and raise the pressure. The gas is used to pressurize the liquid oxygen tank. The gas is not used in any operation of the Space Shuttle Main Engine. Figure 40 depicts a sectional view of the heat exchanger assembly. The liquid oxygen is gasified as it goes through the heat exchanger tubes. From the heat exchanger outlet, the gaseous oxygen goes through a series of valves in the Orbiter to the liquid oxygen tank. The problem we have found is with the weld at the inlet. The

heat exchanger assembly is produced by a subcontractor, Wintech Corporation, located in the Los Angeles area. This heat exchanger was fabricated initially in 1977 (Figure 41). It was initially assigned to a development engine 0006. After it was installed on engine 0006, we had an incident with some internal burning on the fuel powerhead side in October of 1978. It did not do serious damage to the powerhead; therefore, it was retained in the program because it is a high cost item. Subsequently, the powerhead was repaired and installed on engine 0010, another development engine. An incident occurred on engine 0010 in July 1980, resulting in external burning on the engine. A total inspection/reassessment of the powerhead was conducted and it was found to be satisfactory and was then incorporated into engine 2016. Acceptance testing of a total of 931 seconds was conducted at NSTL. Leak tests accomplished at the conclusion of acceptance testing at NSTL indicated no leak in the heat exchanger. Inspection and analyses were made prior to the use in engine 2016 to determine whether the material had been changed by the incident (Figure 42). Inspections included visual examination and thickness and hardness measurements. The powerhead was significantly rebuilt at that time, replacing two pre-burner injectors, the main chamber injector, and a number of the external lines. Because a spare was unavailable at this time, a decision to use this manifold was based on schedule and cost. The hot gas manifold, which is essentially the backbone of the engine, has the longest lead time of over three years. Therefore, it takes 3 plus years for a new engine to be manufactured. Originally, the decision was made to repair and use the powerhead on an R&D engine. Because of flight hardware shortage this repaired powerhead was allocated to a flight engine. Again, analysis indicated that the powerhead was satisfactory for a flight engine. The heat

exchanger was successfully tested prior to engine delivery to Kennedy (Figure 43). A mass spec check of the heat exchanger is performed after each hot firing test. The reason for this check is that it is a very critical component. Each time work is done in the area, a proof test is required with a subsequent leak test. After delivery to Kennedy, the oxidizer pump was replaced. The 3200 psi proof test was conducted and the last mass spec test was failed which indicated evidence of a leak. Further proof testing and mass spec checks verified the leakage. As we are now able to look at the heat exchanger, there is a lack of fusion in the weld (Figure 44). The weld as I pointed out, was made in 1977. Metallurgical analysis verified lack of fusion. It obviously was an error in welding in 1977. All Challenger engines have recently passed proof and mass spec tests (Figure 45). All the heat exchangers in the Challenger engines were fabricated in 1979 or later. Substantial improvements have been made in the weld procedures, processing, and quality assurance program at the subcontractor. Open work at this time is completion of the metallurgical failure analyses and completion of the borescope inspection of the welds on the Challenger engines. The closure of this open work should clear Challenger. Now Jud will update you on where we stand on the engine.

DR. LOVINGOOD: Good morning. Let me just briefly summarize the problem. A crack/leak did occur in the Challenger engine 2015 spark igniter fuel line which initiates the combustion process in the main chamber. After finding the leak, the inside of the line was borescoped inspected on engine 2015 and provided evidence which was very distinct and clear. You are probably aware that there is a design modification at the point where the line goes into the powerhead. The modification made for the 109% engine was not

on the Columbia engines. As a result of the inspection findings on engine 2015, we borescope inspected as many of the engines as possible over the weekend. The result was that of the ten FPL engines inspected which had the sleeve, the design modification; five had the same type of crack that was observed on engine 2015.

CHAIRMAN VOLKMER: Did 2012 have one?

DR. LOVINGOOD: Engine 2012 does have a crack. Engine 2017, which is the third engine, does not have a crack.

CHAIRMAN VOLKMER: That is the third engine we saw at NSTL.

DR. LOVINGOOD: Ten Columbia configuration engines, which do not have a sleeve, were inspected and all engines were found to be acceptable with no evidence of any crack. A significant point is that one of those engines, which is the engine used during the abort demonstration testing, had accumulated 3000 seconds at full power level . So, without the sleeve, even though 3000 seconds has been accumulated; there is no crack. Now as a result of these inspections of engines with and without the sleeve, indications are the cause of the problem is the design change. Plans are to return to the Columbia engine configuration on the three engines which will be flown on Challenger. Engine 2015 will be removed from the vehicle and repaired. It will be in the Vertical Assembly Building (VAB) this afternoon. At the same time, engine 2014 was removed from the NSTL stand and repair is in process. The line will be cut out at the first weld inside the powerhead. A team from Canoga Park, Rocketdyne's manufacturing facility location, along with in plant processing

equipment has been sent to NSTL to do the identical manufacturing processes on 2014 which is done in the Rocketdyne plant. The engine will be a path finder and will resume testing with that repair. The engine will be tested to verify the repair before Challenger is launched.

CHAIRMAN VOLKMER: Which one are you doing at NSTL?

DR. LOVINGOOD: 2014

CHAIRMAN VOLKMER: You are not going to do that for 2017?

DR. LOVINGOOD: We are planning on repairing engine 2017 even though it has no leak or crack because so many of the engines inspected have cracks. Another point is Engine 2010 has over 13,000 seconds, and while it is cracked, it does not leak. Engine 2014 has approximately 9,000 seconds, and while it is cracked, it does not leak. So this shows that from our experience, we have had only one that has leaked out of the ones we have inspected. The certification engines 2010 and 2014 have considerable hot fire time with no problem. Because there is a problem which currently is pointing to the design modification, it is considered wise to repair all the engines.

REPRESENTATIVE LUJAN: Why was the sleeve put into this new engine if now we are going to take it out? Why was it put in, in the first place; some advancement?

DR. LOVINGOOD: When the problem occurred in engine 0010, Mr. Lindstrom mentioned this in his discussion of the heat exchanger problem

regarding the 2016 powerhead experience, a team was established to review and determine if there was anything in the engine that could cause a similar type of problem, especially in the FPL configuration for at that time engine development with a 55 mission use capability was being considered. Team reviewed areas that had never been looked at before; things like small lines to see if they could anticipate potential problems. There was a possibility that when the line was brought through the powerhead, rubbing could occur with eventual rub through and cracking. On one of the engines recently inspected, indications were found of scuff marks on the line. As a result of this concern, a modification was made to a cushion, the sleeve, on the line in order to prevent rubbing.

CHAIRMAN VOLKMER: Is the leak in the line, or is the leak in between the weld through the sleeve and the line?

DR. LOVINGOOD: The leak is in the line. There is no hydrogen in the area between the sleeve and the line, but there is a crack that is occurring, and we haven't received the metallurigal analysis yet to know its cause.

CHAIRMAN VOLKMER: There is one thing I don't fully understand. There is a leak in the line. Are you saying that you have to have a line running the oxygen in there?

DR. LOVINGOOD: Yes, sir. We do have to have a fuel line through the powerhead but we don't have to have the sleeve. The sleeve is not required based on the inspection information on engine configurations without the sleeve, which had no cracks.

CHAIRMAN VOLKMER: But how could the sleeve cause the cracking in the line?

DR. LUCAS: We are not absolutely certain where the crack is, based upon inspections we have been able to make at this point. Inspections made on the engine, without having the material out where we can look at it, indicates that the crack is in the fillet made by the weld. The conjecture is that the parent material of the line may have been embrittled by the process of brazing the sleeve to the line.

CHAIRMAN VOLKMER: The brazing is done to attach the sleeve to the line and in doing that you may have weakened the tube?

DR. LUCAS: That is the conjecture at this point and it looks pretty good. We will know more about this tomorrow when we get the line out of engine 2014 and put it in the lab where we can look at it.

CHAIRMAN VOLKMER: When you don't have the sleeve and you put the line through to the inside, you still have to have a weld there? Do you not?

DR. LOVINGOOD: No, there is not a weld at that point. It just goes straight through the wall and there is a clearance between the outside diameter of the line and the wall of the powerhead.

CHAIRMAN VOLKMER: The whole operation inside is not going to push anything back out through there?

DR. LOVINGOOD: That's right. There is no hydrogen inside. It is just a cavity inside the powerhead. After the line passes through this cavity it is sealed before the hydrogen enters the main injector.

DR. LUCAS: The line goes through two walls that form the cavity. The hydrogen is inside the line. The hole in the cavity is slightly larger than the line. The concern was that the vibration would cause the line to rub against the wall. The sleeve was used to fill the gap and preclude any vibration of the line against these two walls.

CHAIRMAN VOLKMER: Why did you have to braze the sleeve to the line?

DR. LUCAS: The sleeve was brazed to the line to keep it from slipping out, to hold it in place.

CHAIRMAN VOLKMER: Could you have brazed the sleeve to the powerhead itself?

MR. KINGSBURY: The intent was in essence to thicken the walls of the tube.

DR. LOVINGOOD: Let me describe the configuration (Figure 39). There is no hydrogen in this cavity. The line comes in and goes down into the main injector down through this point and is sealed. This is where you have the combustion process. There aren't any combustion gases, hydrogen or oxygen, in this cavity. This sketch is not complete, but the line comes out through the powerhead wall.

CHAIRMAN VOLKMER: Where that line is, there are no gases?

DR. LOVINGOOD: That's right. Bringing the line through here is where the concern was about the line rubbing against this wall. We put the sleeve on to avoid the line rubbing. The line does vibrate because of the vibration of the engine. We are repairing the three Challenger engines. Repairs have been initiated on engine 2014 and we will get the line into laboratory analysis and determine the cause of the crack. In the meantime, we are proceeding with modification of engine 2014 and plan to use the same crew to modify all the Challenger engines. This should be completed before the latter part of next week.

CHAIRMAN VOLKMER: Why couldn't you have used a softer substance other than metal for your sleeve?

DR. LOVINGOOD: We could have done that; in retrospect, we wish we had done that.

DR. LUCAS: In retrospect, it dosen't appear necessary to have done anything.

CHAIRMAN VOLKMER: But you still don't know how long it will last if you did have the problem before with the engine vibration and scuffing?

MR. LINDSTROM: That's right.

DR. LUCAS: It is a life extension kind of decision.

MR. LINDSTROM: Mr. Chairman, in FY-83 we will be supporting four flights and will complete the FPL certification (Figure 46). The flight certification program towards achieving a 7 1/2 hour capability will be initiated. The first flight engine, Columbia engine 2009, will be acceptance tested at a 109% level in August.

CHAIRMAN VOLKMER: Let me go back and ask a question. With the correction you are going to make, are you going to have to remove a part of that tube? Does that mean you are going to have to weld back in a new piece and the hydrogen flow through it? How sure are you that instead of having a solid piece you are going to have to have a welded piece?

MR. LINDSTROM: It is a welded piece now. We do make a weld right in the area we are going to cut. We are going to be able to use the same manufacturing techniques and same tooling that we have used previously. Ultrasonic and radiographic inspection of that weld will be accomplished to insure that it is a good weld. There is no difference in the weld itself, only in terms of doing it in the field as opposed to doing it at the manufacturing site.

CHAIRMAN VOLKMER: You are going to be able to do the same thing that you've done originally?

MR. LINDSTROM: That is correct. The people and tools have come from the home plant and we will be doing that work at NSTL initially on the certification engine.

CHAIRMAN VOLKMER: How long will it take to do that?

DR. LOVINGOOD: It will be a couple of days for each engine from the time it is removed. The disassembly, repairs, inspection and reassembly takes about eight days. The repair of the engines will be in series. Repairs on all four engines, including verification, will be complete by the latter part of next week.

CHAIRMAN VOLKMER: Then are you going to test those engines on the Shuttle?

DR. LOVINGOOD: There is no plan to do that, right now.

MR. LINDSTROM: No, sir. There will be no consideration of another firing of the cluster as such. The engines will be installed and normal checks will be made and then readied for launch.

DR. LUCAS: We will though, after having made the repair on 2014, we will have tested it before the flight of Challenger.

CHAIRMAN VOLKMER: You would assume the same results would be as 2012, 2015, and 2017?

DR. LUCAS: That's right.

MR. LINDSTROM: In summary, (Figure 47) the major emphasis will be flight program support this year. This includes anomaly resolution and determination of the flight readiness of the engines. This completes my discussion of the engines, Mr. Chairman. Do you have any other questions?

CHAIRMAN VOLKMER: Not at this time.

MR. LINDSTROM: I will now briefly cover the External Tank, since you have already received a detailed review at Michoud (Figure 48). The External Tank is being produced by the Martin Marietta Aerospace (MMA) (Figure 49). About 50% of the tank development is by subcontractors mostly with fixed price contracts. Significant testing was accomplished at the Marshall Center using modified existing facilities. A TPS development program, in collaboration with Martin Marietta, is being performed at the MSFC facility; you'll see some of that work on the facility tour this afternoon. Full scale production techniques are tested here and then applied at Michoud.

MR. LUJAN: TPS?

MR. LINDSTROM: Thermal Protection System, which is insulation.
The External Tank program started with the awarding of the contract in 1974 (Figure 51). Four ground test articles were fabricated for development testing including the MPTA, structural tests, and dynamic tests. The four DDT&E flight tanks have been completed and subsequently flown. In September of last year, the lightweight tank, which improves the payload performance, was delivered to KSC and will be used on STS-6. Programs are underway to ensure that both facilities and tooling will be able to achieve the 24 per year flight

rate. A very extensive producibility and production readiness program is in place. A year ago there was some concern about being able to build tanks at the required flight rates but our performance this past year has proven those concerns to be unfounded. The tank program has progressed quite well and a full production program is well underway.

The first lightweight tank, which provides for a payload increase, was delivered to KSC in September 1982 (Figure 52). The actual weight was less than specification weight and the manpower required for fabrication was less than predicted. Also, the nonrecurring costs, the cost required to redesign and retest the tank was below our initial estimate. Figure 53 shows the lightweight tank being mated to the SRB's at KSC. The tank fabrication prime contract has been converted from a cost plus award fee basis to a cost plus incentive fee type arrangement to motivate the contractor to reduce cost, a gain for both the contractor and the government (Figure 54). We are also looking for ways for the contractor to be more self-sufficient. Formerly, the Michoud Assembly Facility was operated as a government facility with the government contracting for a number of facility operations. The operation of the facility has since been transferred to Martin Marietta. Martin Marietta is the primary user of the facility and this responsibility for total facility operation should provide for a reduction in the cost of the tank.

MR. WEEKS: Mr. Chairman, we are trying to move the entire program into a cost plus incentive fee basis, not just with Bill Lucas's program, but with the orbiters and the Kennedy operation. The new Kennedy operation is on incentive contracts. Then perhaps later, we can go to a fixed price incentive

contract. Then maybe eventually to a fixed price contract. So we move from stage to stage as the development status warrents.

MR. LINDSTROM: Figure 55 is a picture of ET-9, which will be used on STS-8, being moved to checkout. The External Tank Project Office is currently in negotiation with Martin Marietta for a block buy of tanks on a CPIF contract; all tanks delivered through FY-85, (Figure 56). In summary, the External Tank Project will continue key project emphases on production rate, cost reduction and sustaining engineering (Figure 57).

I will conclude now with the Shuttle Systems area (Figure 58). The Center does a substantial amount of work in this area. We support the vehicle systems engineering and systems integration in the areas of: main propulsion system, ascent flight systems, loads and dynamics (Figure 59). In fiscal year 1982, for flights 3 through 5, Huntsville Operations Support Center (HOSC) supported our vehicles during ground testing and preparation for launch. The HOSC, shown in Figure 60, is connected to the Kennedy Center Launch Processing System (LPS) and is essential in monitoring our elements: the main engine, main propulsion system, External Tank and the Solid Rocket Booster. This is accomplished with an integrated group of civil service personnel and contractor support. This type of support to the launch reduces the number of people required at the launch site. Testing in association with the Vandenberg launch pad is also being done at MSFC. Currently, the overpressure testing is conducted using a 6.4% configuration of the Shuttle and a scaled down configuration of the Vandenberg launch facility (Figure 61). This area is scheduled during your tour of the Center facilities.

MR. LUJAN: What do you mean by the 6.4% test model?

MR. LINDSTROM: It is a scale model of the Shuttle. It equates to 6.4% of the total 100%.

CHAIRMAN VOLKMER: Is it in scale?

MR. LINDSTROM: It is in scale, in terms of the mass flow of the engines which is the important requirement.

In conjunction with the Air Force, we have been in a support mode in the activation of Vandenberg. We review requirements for Vandenberg as they relate to our programs as well as reviewing their designs to assist the Air Force in the activation of that facility (Figure 59).

Figure 62 shows the main propulsion test set up at NSTL. The Main Propulsion Test program is managed and directed by MSFC (Figure 63). Primary contractors are Rockwell International, Space Systems Group, responsible for the Orbiter systems integration and, in a support capacity, Rocketdyne and Martin Marietta. I believe you saw the configuration when you were at NSTL. I believe we have an aft orbiter fuselage on the MPT stand. The structure simulates the Orbiter with a flight external tank and engines. Of course, there are no engines on the stand at the present time. The first MPT static firing occurred in April 1978 and since that time a total of twelve tests have been conducted (Figure 64). The thrust level for the last MPT test was 102%, previously tests had been at a 100% thrust level. One additional test at a

109% thrust level is planned; however, with our reallocation of engines, at the present time, this test is under review.

CHAIRMAN VOLKMER: Do you use your certification engines for the cluster tests?

MR. LINDSTROM: No sir. We do not use the certification engines. In previous tests we have used an R&D engine. However, for the FPL test we intend to use flight engines. Flight engines will be acceptance tested, individually installed for the cluster firing, and then removed and delivered to an Orbiter. Engines are not specifically bought for the MPT. With our current schedule problems, this program is under review.

In 1983 (Figure 65), we will continue with our main propulsion system and ascent flight system engineering effort with Johnson Space Center (JSC) and again, our effort in support of Vandenburg will increase. We review all their facility designs and also procure some common support equipment for VAFB. This common support equipment amounts to approximately $34 millions, of which we are able to place a significant amount with small businesses and disadvantaged businesses.

Mr. Chairman, in summary, I believe with the exception of completing the certification of the SSME (Figure 66) and, more specifically, the improvements we would like to see in the high pressure pumps, the performance of all our projects have been very excellent this year, from a stand point of schedule performance and costs. All our systems show that they can perform to meet

the operational program. We have a number of programs in place to improve the operational effectiveness of the Shuttle. These programs are directed towards payload improvements, cost reductions, simplifying the launch site operations and obtaining additional SRB and SSME hardware.

Mr. Chairman, this concludes my briefing.

CHAIRMAN VOLKMER: Thank you.

DR. LUCAS: Mr. Chairman, if there are no questions on the Shuttle, we will move to the Space Telescope, and Dr. Fred Speer, who is our Manager of that Project, will make that presentation.

[The information requested on p. 9 by Chairman Volkmer, plus figures 1-66 of Mr. Lindstrom's oral presentation follow:]

Material requested for the record on page 9 by Chairman Volkmer during the hearing before the House Subcommittee on Space Science and Applications, February 28, 1983.

Based on the current mission model the cost in FY 1983 dollars for the last Solid Rocket Booster (SRB) delivered in FY 1984 (STS-20) is $24.0 million, which includes assembly labor and expendable material such as Solid Rocket Motor (SRM) propellants, but does not include the amortization of SRB reusable hardware.

Also, based on current mission model, the cost in FY 1983 dollars for the External Tank delivered in FY 1984 (ET-24) is $25.8 million.

AGENDA

- MSFC SPACE SHUTTLE ROLE
- SOLID ROCKET BOOSTER
- SPACE SHUTTLE MAIN ENGINE
- EXTERNAL TANK
- SHUTTLE SYSTEMS

FIGURE 1

SOLID ROCKET BOOSTER PROJECT

- CHARACTERISTICS
- PROJECT SUMMARY
- ACCOMPLISHMENTS
- FY 83 ACTIVITIES
- KEY PROJECT EMPHASES

FIGURE 4

MSFC SPACE SHUTTLE ROLE

- DDT&E
  - DEVELOPMENT AND CERTIFICATION
    - EXTERNAL TANK
    - SOLID ROCKET BOOSTER
    - SPACE SHUTTLE MAIN ENGINE
  - PROPULSION SYSTEM TESTING
  - PROPULSION AND ASCENT FLIGHT SYSTEM INTEGRATION
  - PERFORMANCE IMPROVEMENTS
- SUPPORT TO OPERATIONS
  - PRODUCTION AND LOGISTICS SUPPORT OF MAJOR ELEMENTS – ET, SRB, & SSME
  - LAUNCH SUPPORT FOR KSC AND VAFB
  - VAFB ACTIVATION
  - OPERATIONAL IMPROVEMENTS
    - PRODUCIBILITY
    - REQUIREMENTS REDUCTION
    - COST REDUCTION
    - LAUNCH PROCESSING SIMPLIFICATION

FIGURE 2

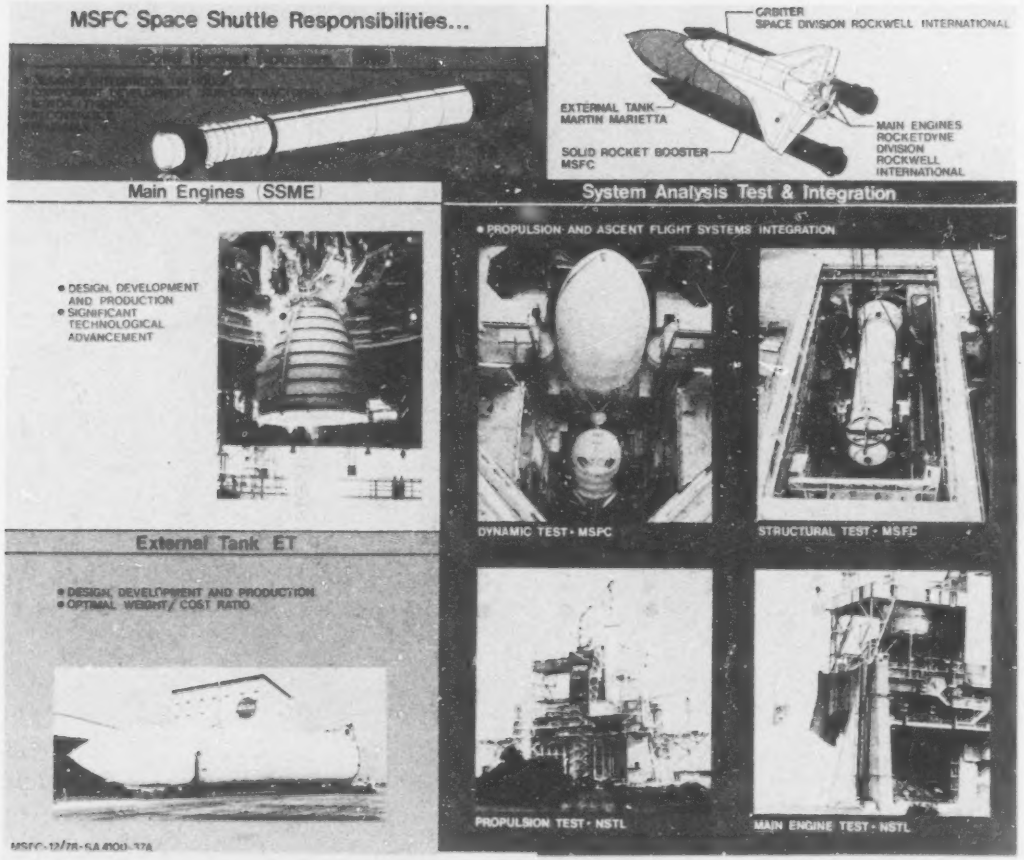
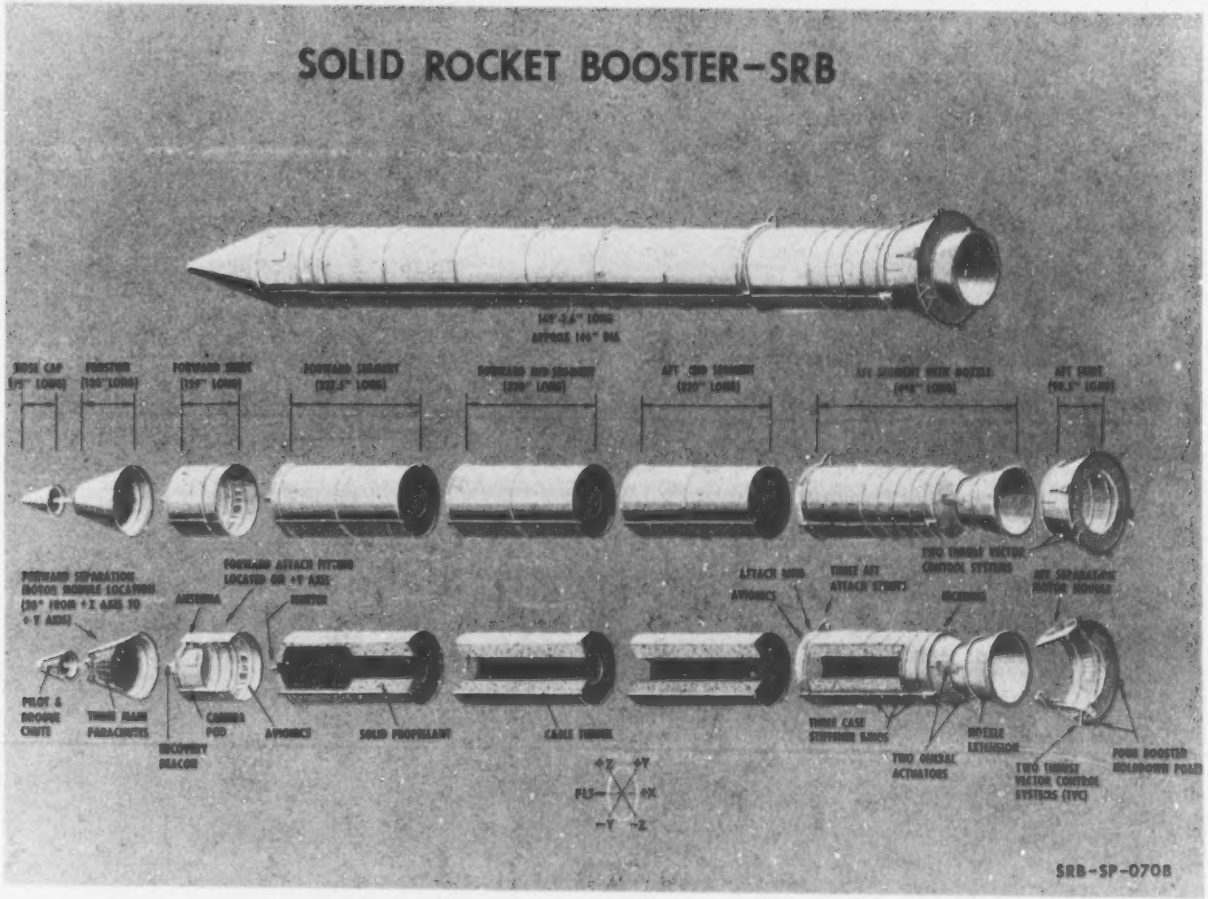

MSFC Space Shuttle Responsibilities...
ORBITER
SPACE DIVISION ROCKWELL INTERNATIONAL
EXTERNAL TANK
MARTIN MARIETTA
SOLID ROCKET BOOSTER
MSFC
MAIN ENGINES
ROCKETDYNE
DIVISION
ROCKWELL
INTERNATIONAL
Main Engines (SSME)
• DESIGN, DEVELOPMENT AND PRODUCTION
• SIGNIFICANT TECHNOLOGICAL ADVANCEMENT
External Tank ET
• DESIGN, DEVELOPMENT AND PRODUCTION
• OPTIMAL WEIGHT/ COST RATIO
System Analysis Test & Integration
• PROPULSION AND ASCENT FLIGHT SYSTEMS INTEGRATION
DYNAMIC TEST - MSFC
STRUCTURAL TEST - MSFC
PROPULSION TEST - NSTL
MAIN ENGINE TEST - NSTL

FIGURE 3


SOLID ROCKET BOOSTER–SRB
149'-1.6" LONG
APPROX 144" DIA
NOSE CAP (95" LONG)
FRUSTUM (100" LONG)
FORWARD SKIRT (159" LONG)
FORWARD SKIRT (327.5" LONG)
FORWARD AFT SKIRT (220" LONG)
AFT SKIRT (220" LONG)
AFT SKIRT (98.5" LONG)
FORWARD SEPARATION MOTOR NOZZLE LOCATION (20° FROM +Z AXIS TO +Y AXIS)
FORWARD ATTACH FITTING LOCATED ON +Y AXIS
ANTENNA
MOTOR
ATTACH AFT AVIONICS
THREE AFT ATTACH STRUTS
TWO THRUST VECTOR CONTROL SYSTEMS
AFT SEPARATION MOTOR NOZZLE
PILOT & BOOSTER CHUTE
THREE MAIN PARACHUTES
RECOVERY BEACON
CAMERA POD
AVIONICS
SOLID PROPELLANT
CABLE TUNNEL
THREE CASE STIFFENER RINGS
TWO GIMBAL ACTUATORS
NOZZLE EXTENSION
TWO THRUST VECTOR CONTROL SYSTEMS (TVC)
FOUR BOOSTER HOLDDOWN POSTS
+Z +Y
PLS +X
–Y –Z
SRB-SP-0708

SOLID ROCKET BOOSTER (SRB)

- **MARSHALL RESPONSIBILITY**

  RESEARCH AND DEVELOPMENT OF THE SOLID ROCKET BOOSTER. THE PRIMARY ELEMENTS OF THE BOOSTER ARE THE 2.9 MILLION POUND THRUST MOTORS: FORWARD AND AFT STRUCTURES: SEPARATION AND RECOVERY, AVIONICS, AND THRUST VECTOR CONTROL SUBSYSTEMS.

- **MAJOR CONTRACTORS**

SOLID ROCKET MOTOR	–	THIOKOL CORPORATION
BOOSTER ASSEMBLY	–	UNITED SPACE BOOSTERS INCORPORATED
STRUCTURES	–	MCDONNELL DOUGLAS ASTRONAUTICS CO.
SEPARATION MOTORS	–	UNITED TECHNOLOGY CORPORATION
RECOVERY SUBSYSTEM	–	MARTIN MARIETTA – DENVER
THRUST VECTOR CONTROL	–	MOOG INCORPORATED
INTEGRATED ELECTRONICS ASSEMBLY	–	BENDIX CORPORATION

- **TEST FACILITIES**

THIOKOL	–	LARGE MOTOR TESTING
MARSHALL	–	SRB STRUCTURAL TESTING

FIGURE 6

SRB/SRM
PROJECT SUMMARY

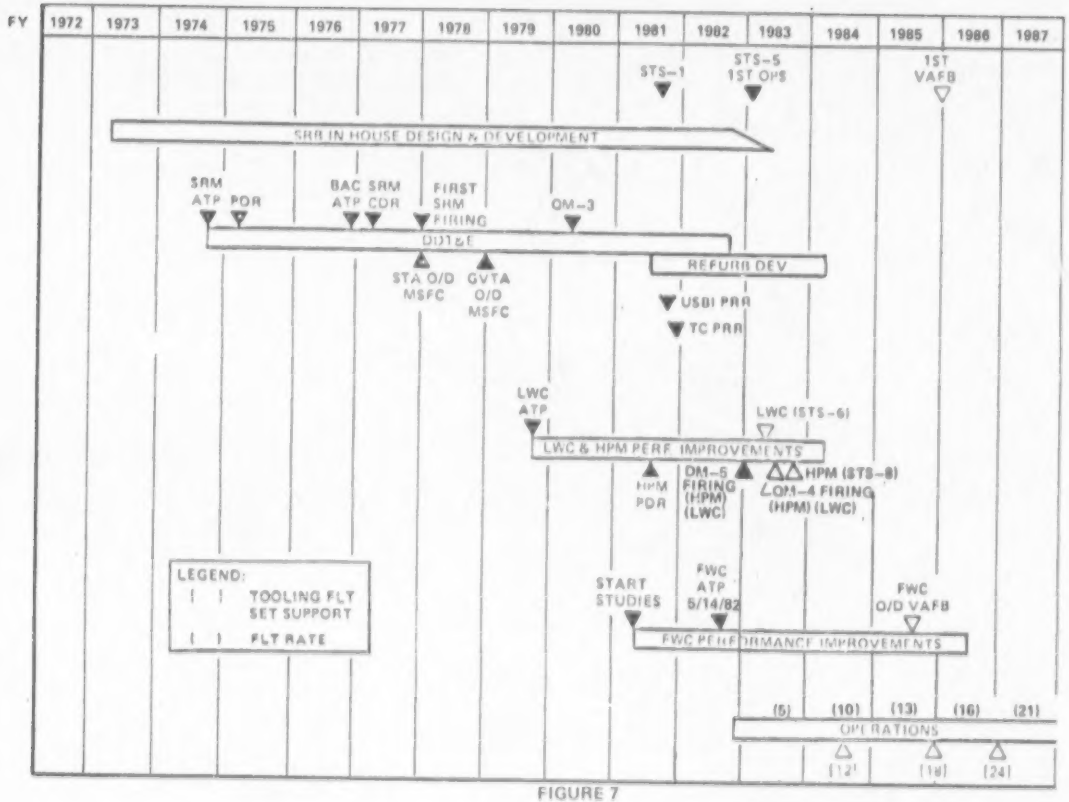


FIGURE 7

FIGURE 8

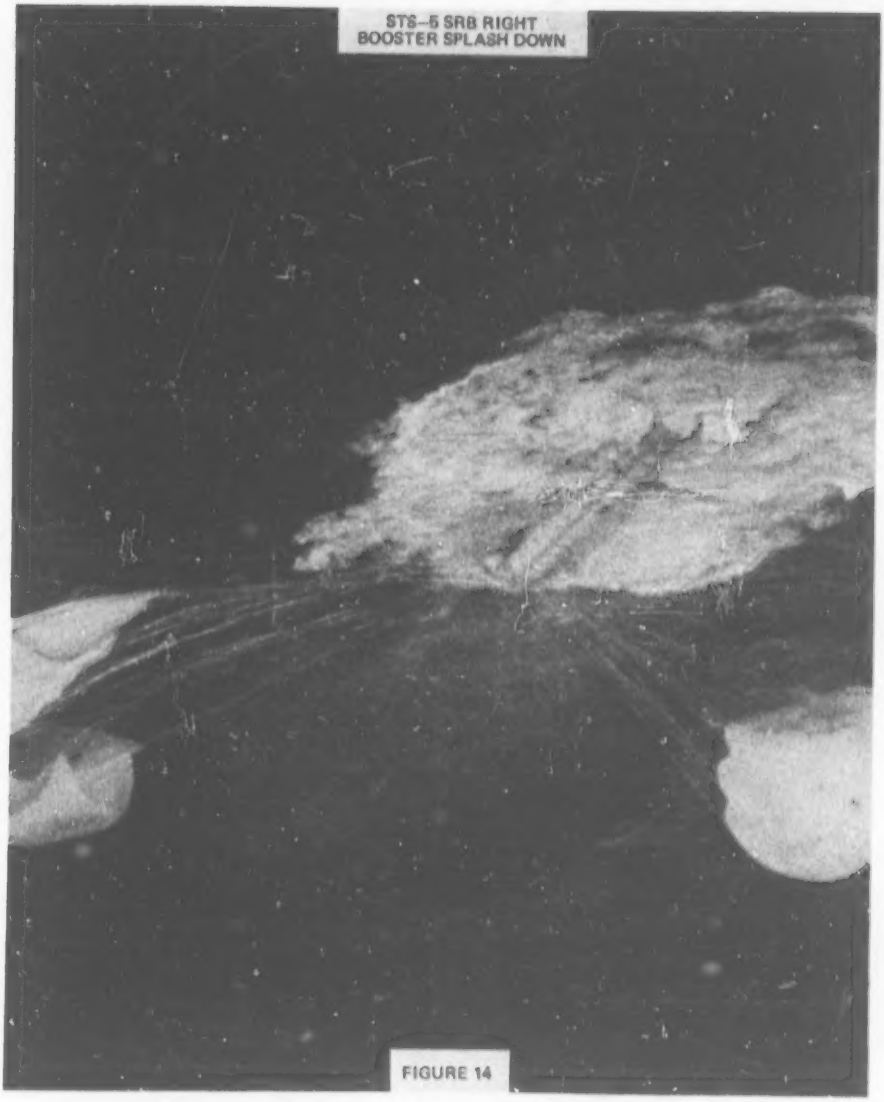
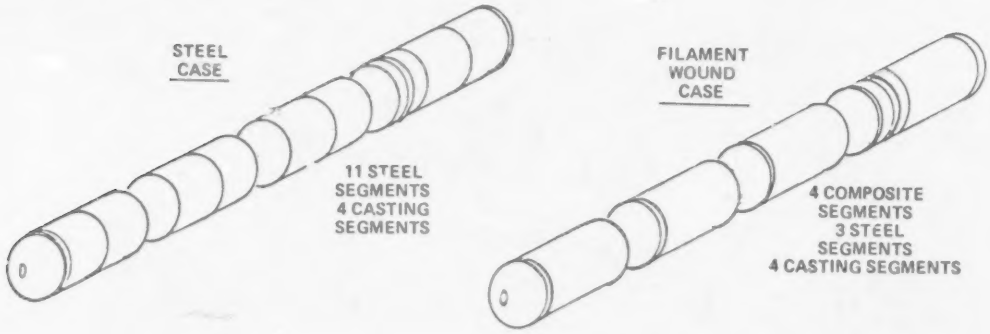


FIGURE 14

FWC HARDWARE DESCRIPTION

FWC INCORPORATES SUBSTITUTION OF FILAMENT WOUND STRUCTURES FOR STEEL SEGMENTS IN CYLINDRICAL PORTIONS OF THE SRM CASE



FWC KEY REQUIREMENTS

INCORPORATE FWD, AFT, AND ATTACH SEGMENTS FROM STEEL CASE UNMODIFIED

PROPELLANT, PROPELLANT GRAIN, NOZZLE, IGNITER INTERFACES, INTERNAL GEOMETRY UNCHANGED

STATE OF THE ART DESIGN AND PROCESSES TO BE USED

ATP: MAY, '82 – FIRST FLIGHT: OCT, '85

MAXIMUM CASE WEIGHT: 65,000 LBS (Δ WT = 33,500 LBS, PAYLOAD GAIN = 5,500 LBS)

CASE STIFFNESS:
- BENDING/AXIAL: ET = 10×10^6 LB/IN
- AXIAL GROWTH: 0.6 IN NOMINAL
- RADIAL GROWTH: 0.5 IN (FWD SEGMENT)

CASE TO BE RECOVERABLE
- METAL PARTS REUSABLE 19 TIMES
- COMPOSITE MATERIAL REUSABILITY TO BE ASSESSED

FIGURE 9

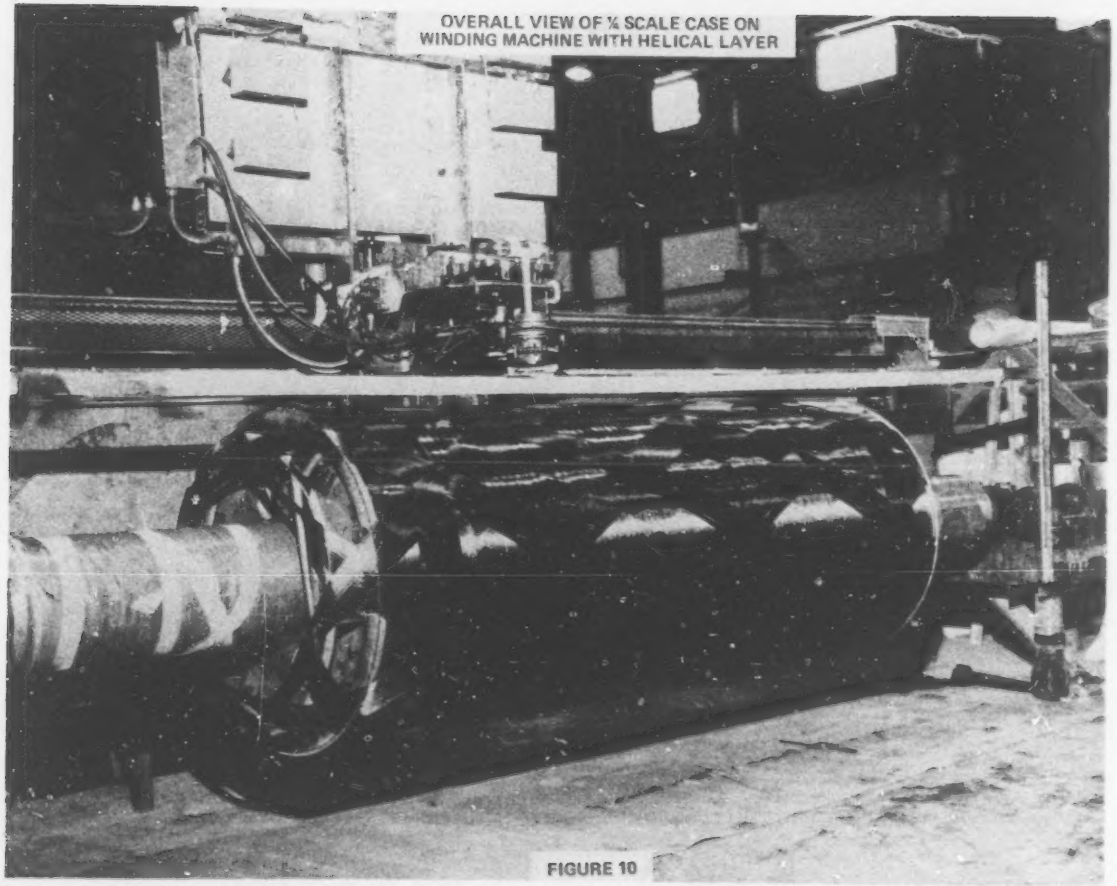

OVERALL VIEW OF ¼ SCALE CASE ON
WINDING MACHINE WITH HELICAL LAYER

FIGURE 10

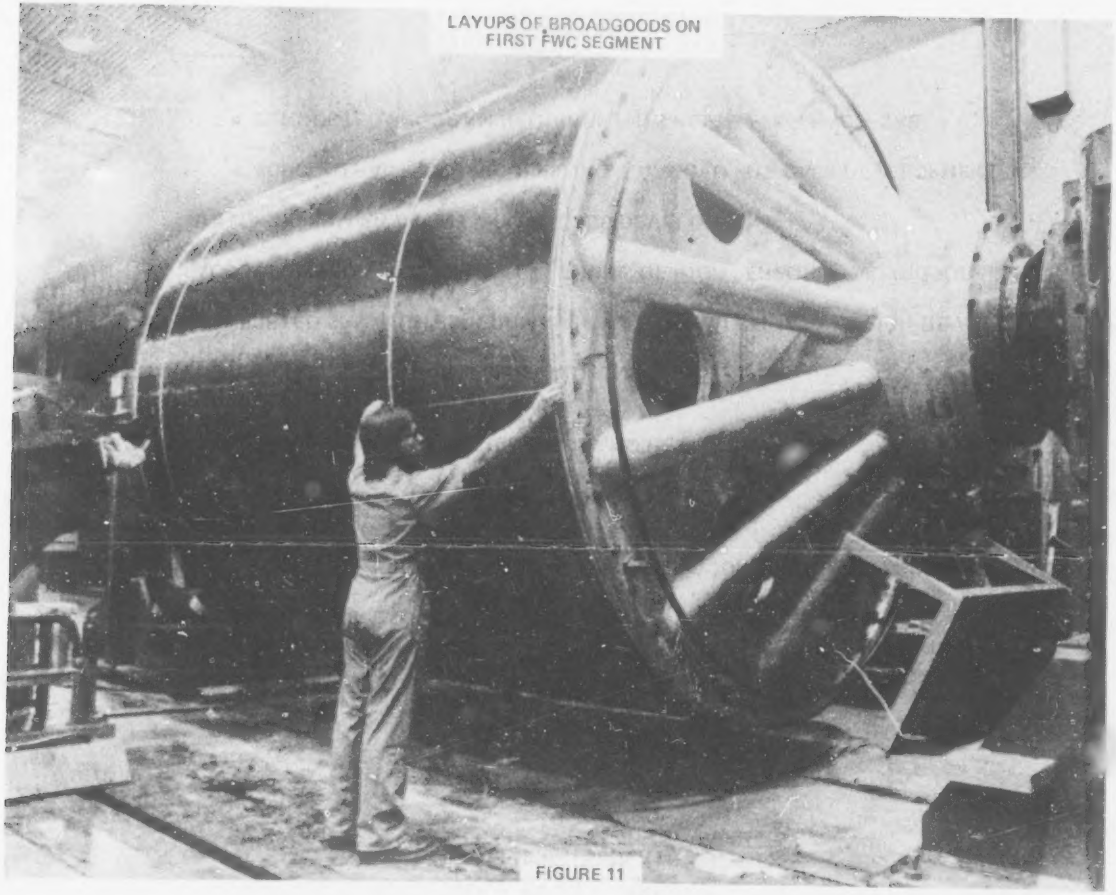


FIGURE 11

SOLID ROCKET BOOSTER
ACCOMPLISHMENTS

- **DDT&E**
  - COMPLETED SUCCESSFUL LAUNCH AND RECOVERY OF STS–3 BOOSTERS
  - COMPLETED SUCCESSFUL LAUNCH OF STS–4; HOWEVER, BOOSTERS LOST IN OCEAN BECAUSE OF MALFUNCTIONING OF PARACHUTE RELEASE SYSTEM
  - INCORPORATED FIX FOR STS–4 RECOVERY SYSTEM FAILURE
  - CONTINUED FLIGHT HARDWARE DESIGN MODS AND REPAIR TO REDUCE WATER IMPACT DAMAGE AND TO IMPROVE KSC HARDWARE FLOW
  - INITIATED PERFORMANCE ENHANCEMENT ACTIONS
    - COMPLETED SRM HIGH PERFORMANCE MOTOR PRELIMINARY DESIGN REVIEW
    - ACCOMPLISHED SUCCESSFUL TEST FIRING OF HIGH PERFORMANCE MOTOR (DM–5)
    - INITIATED SRM FILAMENT WOUND CASE DEVELOPMENT
      - SUBCONTRACT TO HERCULES, INC. AWARDED FOR CASE DEVELOPMENT
      - CONDUCTED PROGRAM REQUIREMENTS REVIEW FOR FWC – SRB

1000

FIGURE 12

SOLID ROCKET BOOSTER
ACCOMPLISHMENTS (CONT'D)

- SUPPORT TO OPERATIONS
  - COMPLETED SUCCESSFUL LAUNCH AND RECOVERY OF STS–5 (FIRST OPERATIONAL SHUTTLE FLIGHT) BOOSTERS
  - MAINTAINED STS–6 AND STS–7 HARDWARE MANUFACTURING AND ASSEMBLY OPERATIONS ON SCHEDULE – DELIVERIES COMPLETED
  - CONDUCTED DELTA PRODUCTION READINESS REVIEW (PRR) AT THIOKOL
  - COMPLETED REQUIREMENTS REDUCTION REVIEW AND INITIATED ACTIVITY TO INCORPORATE REDUCED REQUIREMENTS
  - DEFINITIZED LETTER CONTRACT FOR STS–7 AND 8 BOOSTER ASSEMBLY EFFORT AND LIMITED HARDWARE PROCUREMENT THROUGH STS–27.
  - AWARDED LETTER CONTRACT FOR SECOND BUY OF BOOSTER ASSEMBLY EFFORT (STS–9 THROUGH 16)
  - REACHED AGREEMENT WITH SRM CONTRACTOR ON COST AND INCENTIVE FEE STRUCTURE OF CONTRACT FOR STS–7 THROUGH 15.
  - EXPLORED SEVERAL FACILITY ARRANGEMENT OPTIONS TO LOCATE A SOLID ROCKET BOOSTER REFURBISHMENT AND ASSEMBLY FACILITY

FIGURE 13

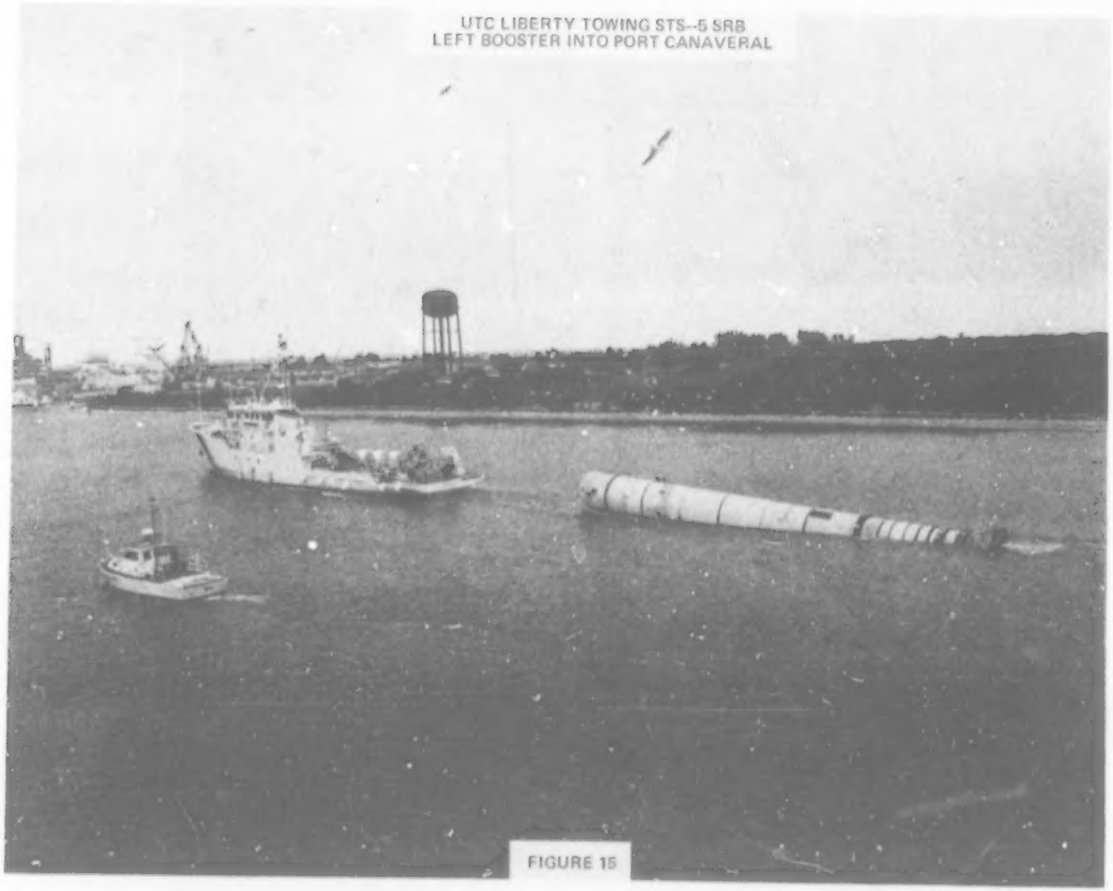

UTC LIBERTY TOWING STS--5 SRB
LEFT BOOSTER INTO PORT CANAVERAL

FIGURE 15

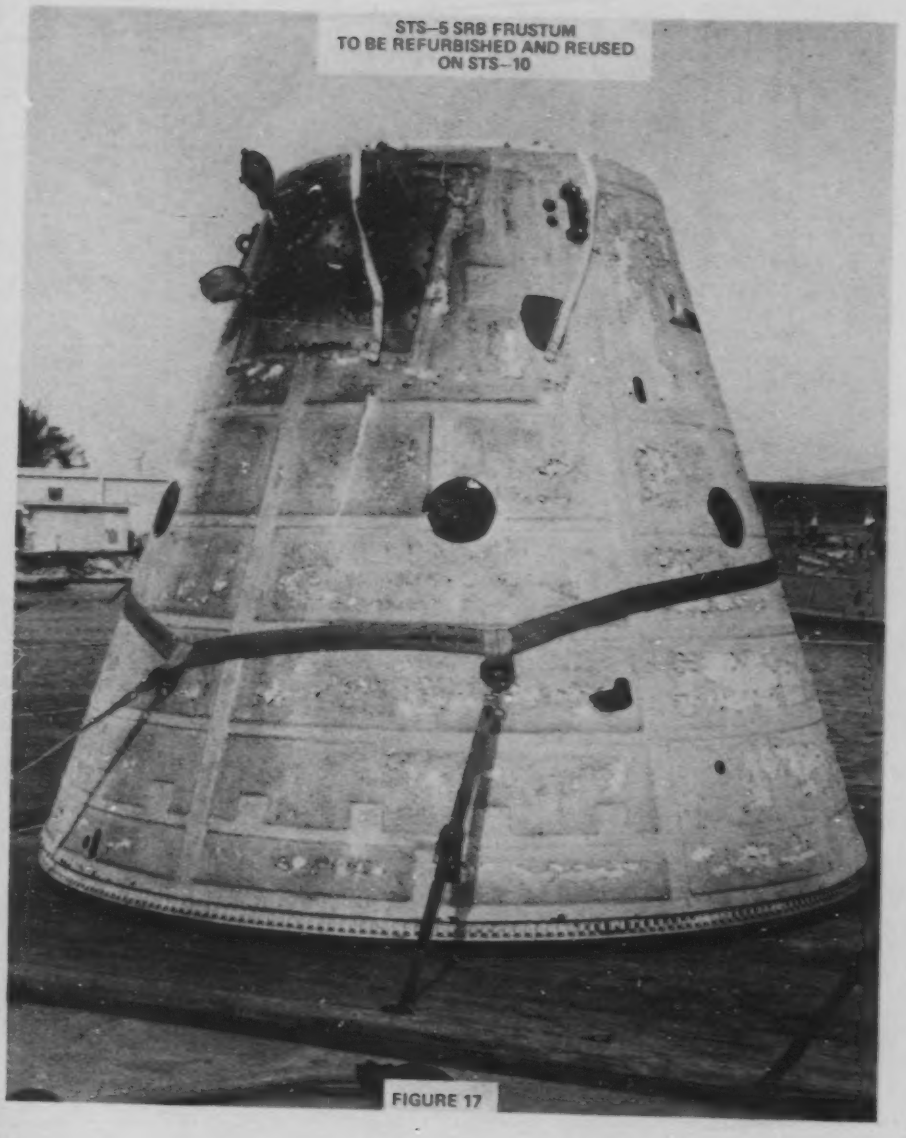


FIGURE 17

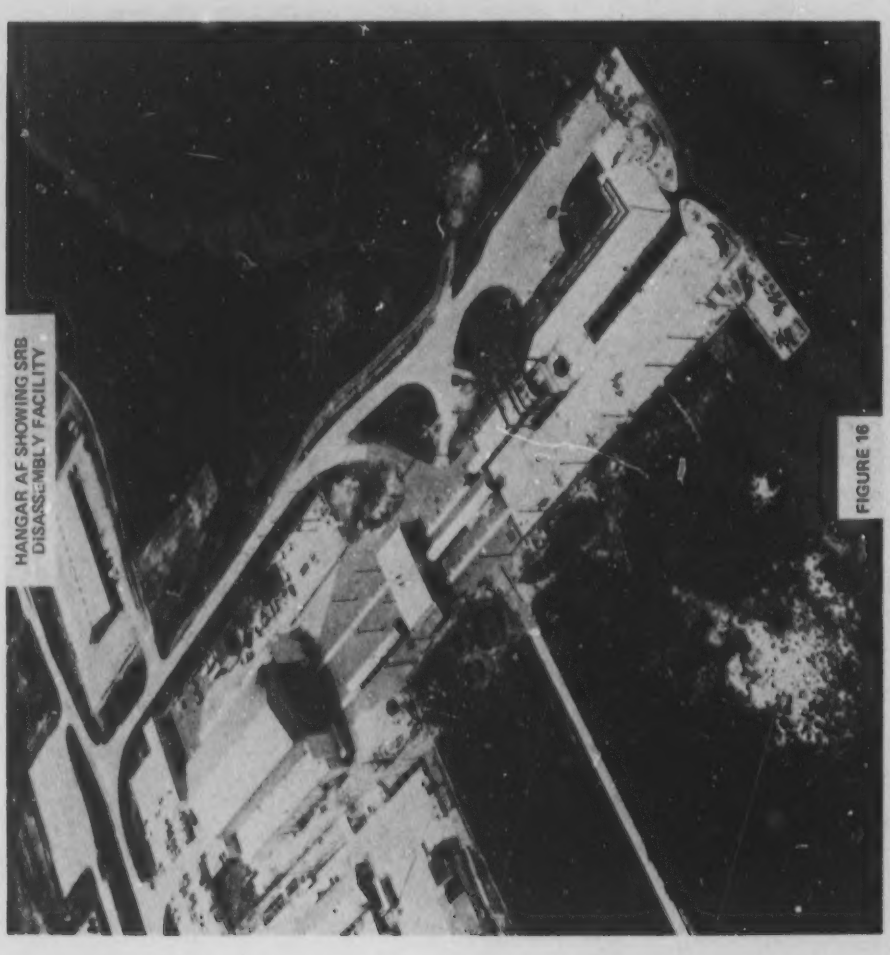
STS-5 POST – FLIGHT ASSESSMENT OF RECOVERED SRB

FIGURE 18

SPACE SHUTTLE MAIN ENGINE PROJECT

- CHARACTERISTICS
- PROJECT SUMMARY
- ACCOMPLISHMENTS
- CHALLENGER ENGINE STATUS
- FY 83 ACTIVITIES
- KEY PROJECT EMPHASES

FIGURE 21



HANGAR AF SHOWING SRB DISASSEMBLY FACILITY

FIGURE 16

SOLID ROCKET BOOSTER
FY-83 ACTIVITIES

- **CAPABILITY DEVELOPMENT**
  - COMPLETE HARDWARE DESIGN TO REDUCE WATER IMPACT AND IMPROVE KSC HARDWARE FLOW
  - CONTINUE DEVELOPMENT OF THE SRM FILAMENT WOUND CASE WITH COMPLETION OF CASE DESIGN, SUBSCALE TESTING, REUSABILITY/REFURBISHMENT STUDIES, ETC.
  - CONDUCT TEST FIRING OF HIGH PERFORMANCE MOTOR (QM–4)

- **SUPPORT TO OPERATIONS**
  - COMPLETE DELIVERIES OF SRM'S AND BOOSTER ASSEMBLIES FOR STS–8 THROUGH STS–10
  - DEFINITIZE CPIF CONTRACT ON MOTORS FOR STS–7 THROUGH STS–15 AND ISSUE RFP ON MOTORS FOR STS–16 THROUGH STS–32
  - DEFINITIZE CONTRACT WITH CONVERSION FROM CPAF TO CPIF ON BOOSTER ASSEMBLY EFFORT FOR STS–9 THROUGH STS–16
  - PRODUCTION FACILITY SELECTION BY ADMINISTRATOR
  - CONDUCT DELTA PRODUCTION READINESS REVIEW AT USBI

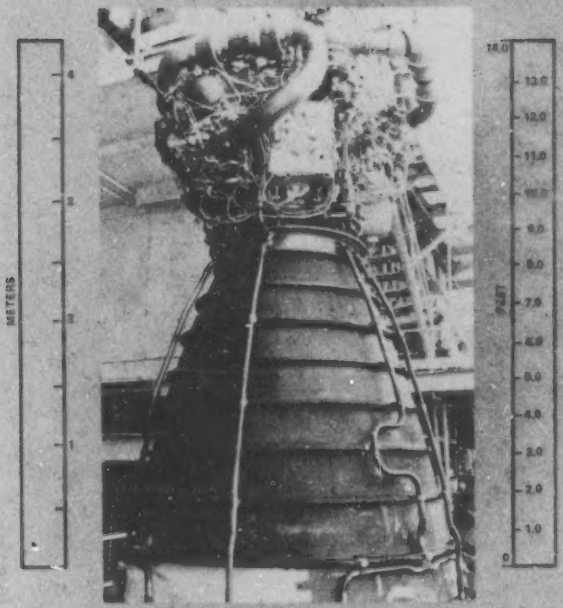
FIGURE 19

SOLID ROCKET BOOSTER
KEY PROJECT EMPHASES

- VEHICLE PERFORMANCE ENHANCEMENT – FILAMENT WOUND CASE
  - CRITICAL DESIGN REVIEW
  - CASE FABRICATION
- ATTAINMENT OF PRODUCTION RATE CAPABILITY – 10 FLIGHTS REQUIRED FY–84
  - TOOLING
  - FACILITIES
  - PRODUCTION READINESS
- COST REDUCTION
  - REQUIREMENTS
  - PRODUCIBILITY
  - INCENTIVE CONTRACTING
- SUSTAINING ENGINEERING
  - FLIGHT SUPPORT
  - ANOMALY RESOLUTION
  - FLIGHT READINESS
- SRB OPERATIONS IMPROVEMENTS

FIGURE 20

SPACE SHUTTLE MAIN ENGINE CHARACTERISTICS



• THRUST		
• SEA LEVEL	375K	(1,668,360 N)
• VACUUM	470K	(2,090,660 N)
• FPL	109%	109%
• CHAMBER PRESSURE	2970 PSIA	2,458 N/cm²
• AREA RATIO	77.5	77.5
• SPECIFIC IMPULSE (NOM		
• SEA LEVEL	363.2	3562 $\frac{N \cdot sec}{kg}$
• VACUUM	455.2	4464 $\frac{N \cdot sec}{kg}$
• MIXTURE RATIO	6.0	6.0
• LENGTH	167"	424 cm
• DIAMETER		
• POWERHEAD	105" x 95"	267 x 240 cm
• NOZZLE EXIT	94"	239 cm
• LIFE	7.5 HRS	7.5 HRS
	55 STARTS	55 STARTS

MSFC-10/81-SA 414d

FIGURE 22

ENGINE 2011

MAIN COMBUSTION CHAMBER

MANIFOLD CRACK

FIGURE 29

SPACE SHUTTLE MAIN ENGINE (SSME)

- **MSFC RESPONSIBILITY**

  RESEARCH, DEVELOPMENT AND PRODUCTION OF THE SPACE SHUTTLE MAIN ENGINE, A HIGH PERFORMANCE, REUSABLE, THROTTLABLE ENGINE FOR THE ORBITER. THE 470K THRUST ENGINE BURNS LIQUID HYDROGEN/ LIQUID OXYGEN, WITH AN EXPECTED LIFE OF 7.5 HOURS AND 55 STARTS.

- **PRIME CONTRACTOR**

  - ROCKETDYNE DIVISION, ROCKWELL INTERNATIONAL CORPORATION

- **MAJOR SUBCONTRACTORS**

  - HONEYWELL, INC. – CONTROLLER
  - HYDRAULIC RESEARCH, INC. – HYDRAULIC ACTUATORS FOR ENGINE VALVE CONTROL

- **TEST SITES**

  - NATIONAL SPACE TECHNOLOGY LABORATORIES – 2 STANDS
  - SANTA SUSANA FIELD LABORATORY – 1 STAND

FIGURE 23

SPACE SHUTTLE MAIN ENGINE
PROJECT SUMMARY

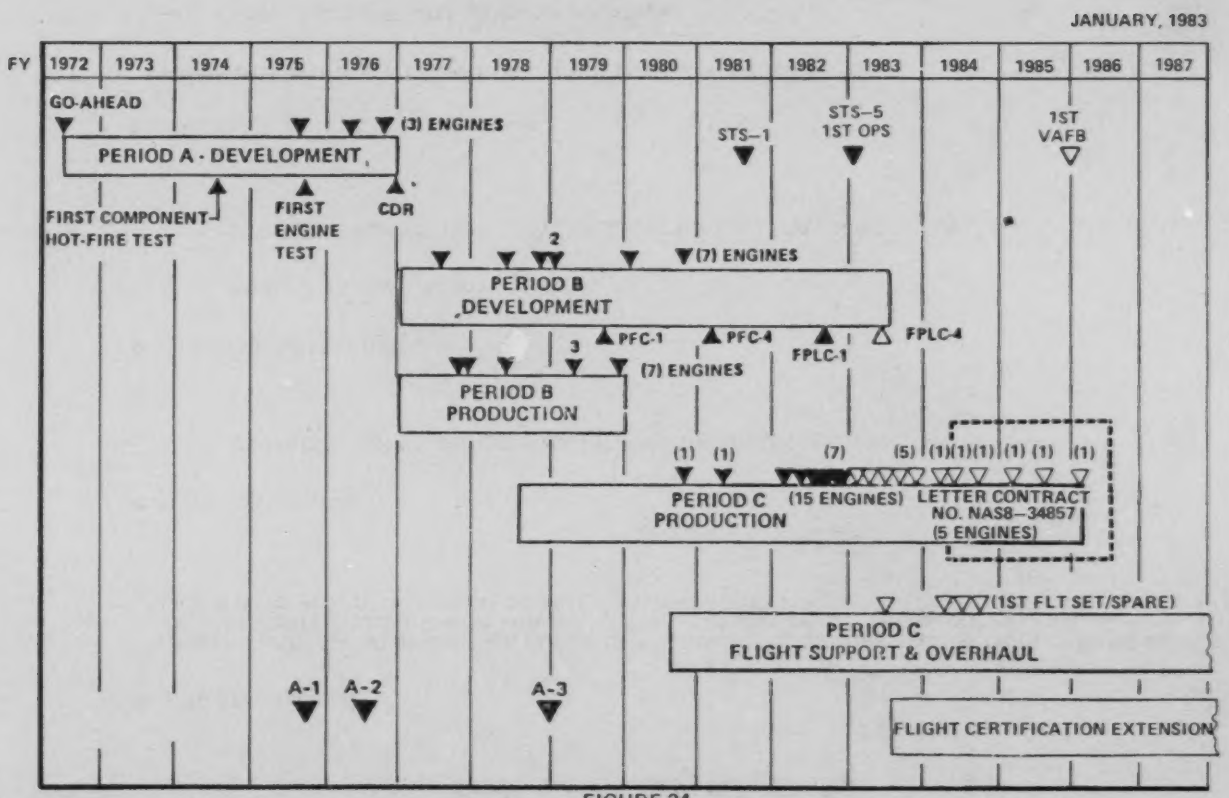


FIGURE 24

SPACE SHUTTLE MAIN ENGINE

ACCOMPLISHMENTS

- COLUMBIA FLIGHT ENGINE EXPERIENCE OUTSTANDING
  - STS–3 THROUGH STS–5 SUCCESSFUL
  - NO FLIGHT PROBLEMS ENCOUNTERED
  - INSPECTION/MAINTENANCE CAPABILITY DEMONSTRATED
  - ENGINE REUSEABILITY DEMONSTRATED
- CONTINUED TO DEMONSTRATE RELIABILITY – 20,000 SECONDS ON A SINGLE TEST ENGINE 172,000 TOTAL SECONDS
- CONTINUED FULL POWER LEVEL (FPL) TESTING ON ALL THREE TEST STANDS
  - SIGNIFICANT PROBLEMS
    - HIGH PRESSURE FUEL TURBOPUMP (HPFTP) OPERATING TEMPERATURE
    - HIGH PRESSURE OXIDIZER TURBOPUMP (HPOTP) BEARINGS AND SUBSYNCHRONOUS WHIRL
  - MODIFICATIONS IN TEST
    - FUEL PREBURNER MOD FOR COOLER OPERATING HPFTP
    - IMPROVED HPFTP SEALS FOR COOLER OPERATION
    - IMPROVED HPOTP BEARING ASSEMBLIES

FIGURE 25

SA51–5063o

SUMMARY OF ENGINE TEST POWER LEVEL OPERATION

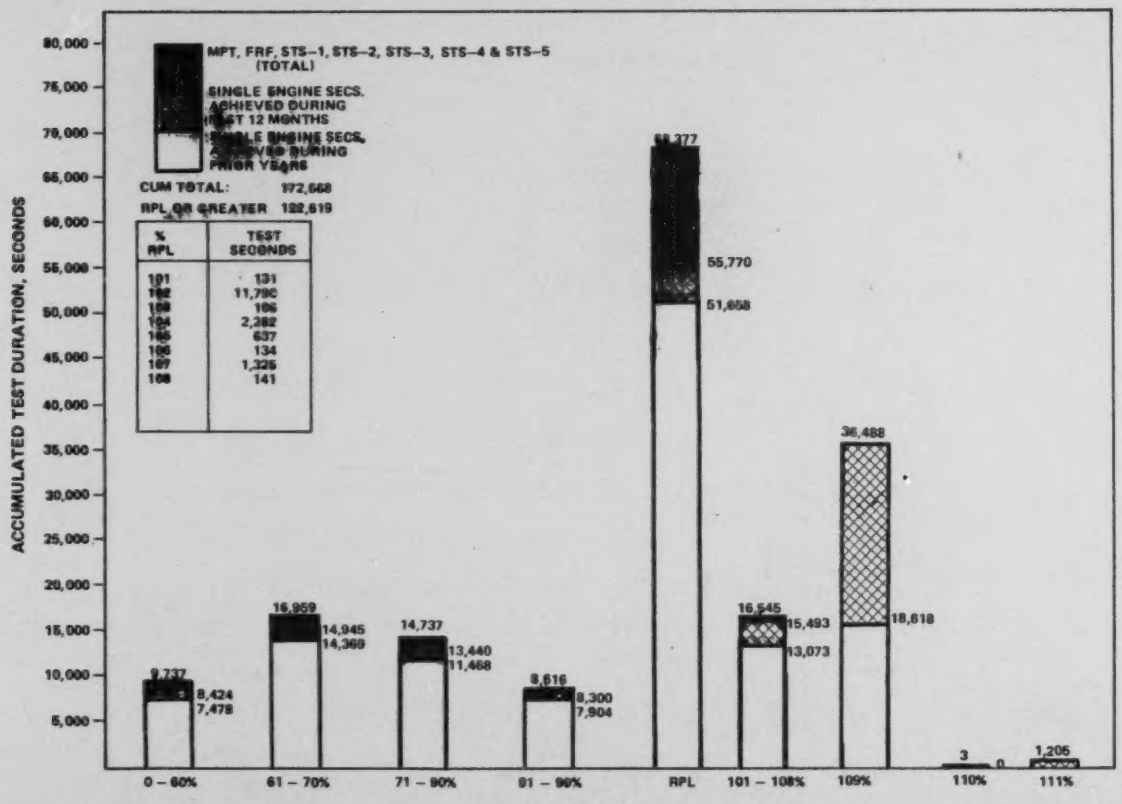


FIGURE 26

1–31–83

SPACE SHUTTLE MAIN ENGINE ACCOMPLISHMENTS (CONT'D)

- FULL POWER LEVEL CERTIFICATION PROCEEDING
  - ENGINES 2010 AND 2014
  - TWO CYCLES – COMPLETE – ENGINE 2010
  - ONE CYCLE – COMPLETE – ENGINE 2014; SECOND CYCLE (ECD FEBRUARY 1983)
- CHALLENGER ENGINES (SECOND FLIGHT SET) DELIVERED
  - FLIGHT READINESS FIRING CONDUCTED DECEMBER 18, 1982
    - HIGH GASEOUS HYDROGEN CONCENTRATION IN AFT COMPARTMENT
  - FLIGHT READINESS FIRING REPEATED JANUARY 25, 1983
    - HYDROGEN LEAK DISCOVERED IN ENGINE # 1 – ENGINE REPLACED
    - GASEOUS OXYGEN LEAK DISCOVERED ON REPLACEMENT ENGINE DURING CHECKOUT – INVESTIGATION IN PROGRESS
- ENGINE BUILD SCHEDULES BEING MAINTAINED

FIGURE 27

FLIGHT CERTIFICATION SUMMARY

(FPL)

CERTIFICATION OBJECTIVES	CERTIFICATION CYCLE REQUIREMENTS	ENGINE 2010		ENGINE 2014	
		1ST CYCLE	2ND CYCLE	1ST CYCLE	2ND CYCLE
TOTAL TESTS	13	15	13	15	8
STARTS TO RATED POWER LEVEL	13	14	13	14	8
TOTAL DURATION (SEC)	5000 (MIN.)	5026	5305	5107	3050
TIME AT FULL POWER LEVEL	3000 (MIN.)	3145	3503	3513	2260
TIME ABOVE FULL POWER LEVEL (111%)	380	380	380	380	0
MISSION DURATIONS	8	8	8	8	5
NOMINAL MISSIONS (500 SEC)	6	6	6	6	5
ABORT TO ORBIT (595 SEC)	1	1	1	1	0
RETURN TO LAUNCH SITE ABORT (750 SEC)	1	1	1	1	0
SCHEDULE COMPLETION DATES		FEB 1982A	JUN 1982 A	AUG 1982 A	FEB 1983

FIGURE 28

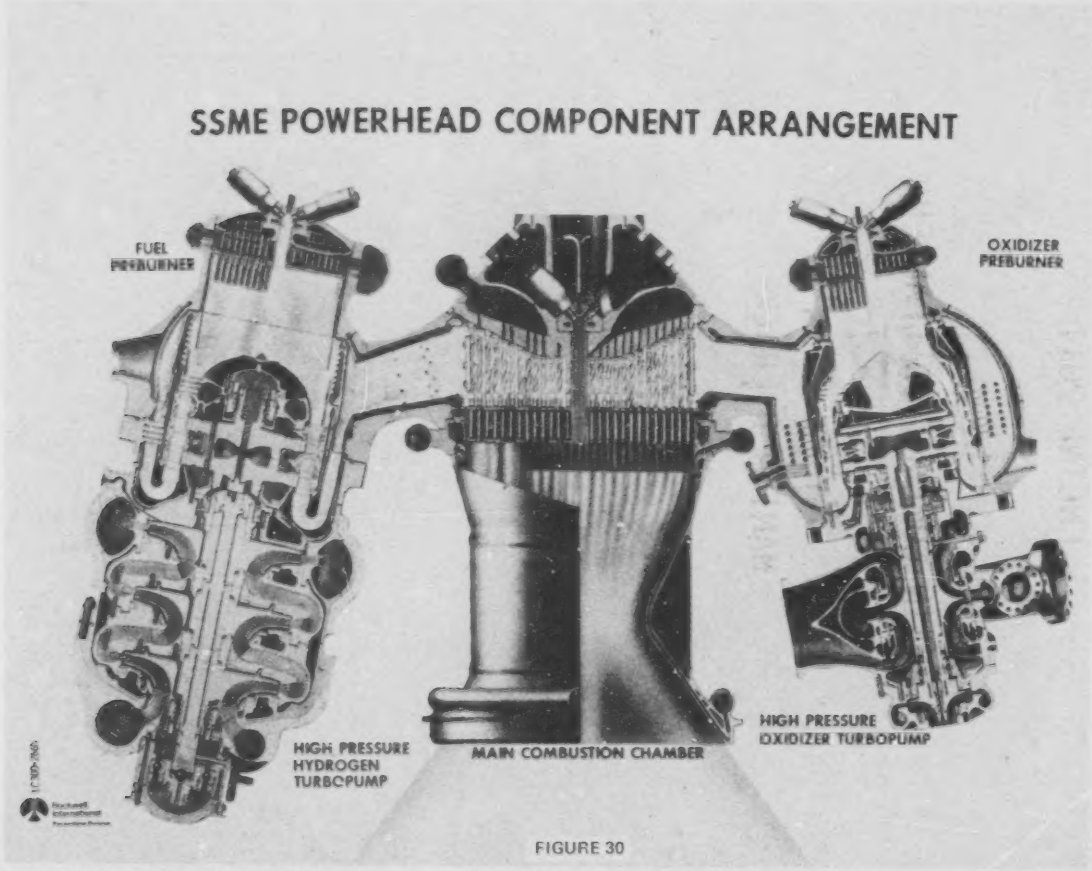

SSME POWERHEAD COMPONENT ARRANGEMENT
FUEL PREBURNER
OXIDIZER PREBURNER
HIGH PRESSURE HYDROGEN TURBOPUMP
MAIN COMBUSTION CHAMBER
HIGH PRESSURE OXIDIZER TURBOPUMP

FIGURE 30

FIGURE 31

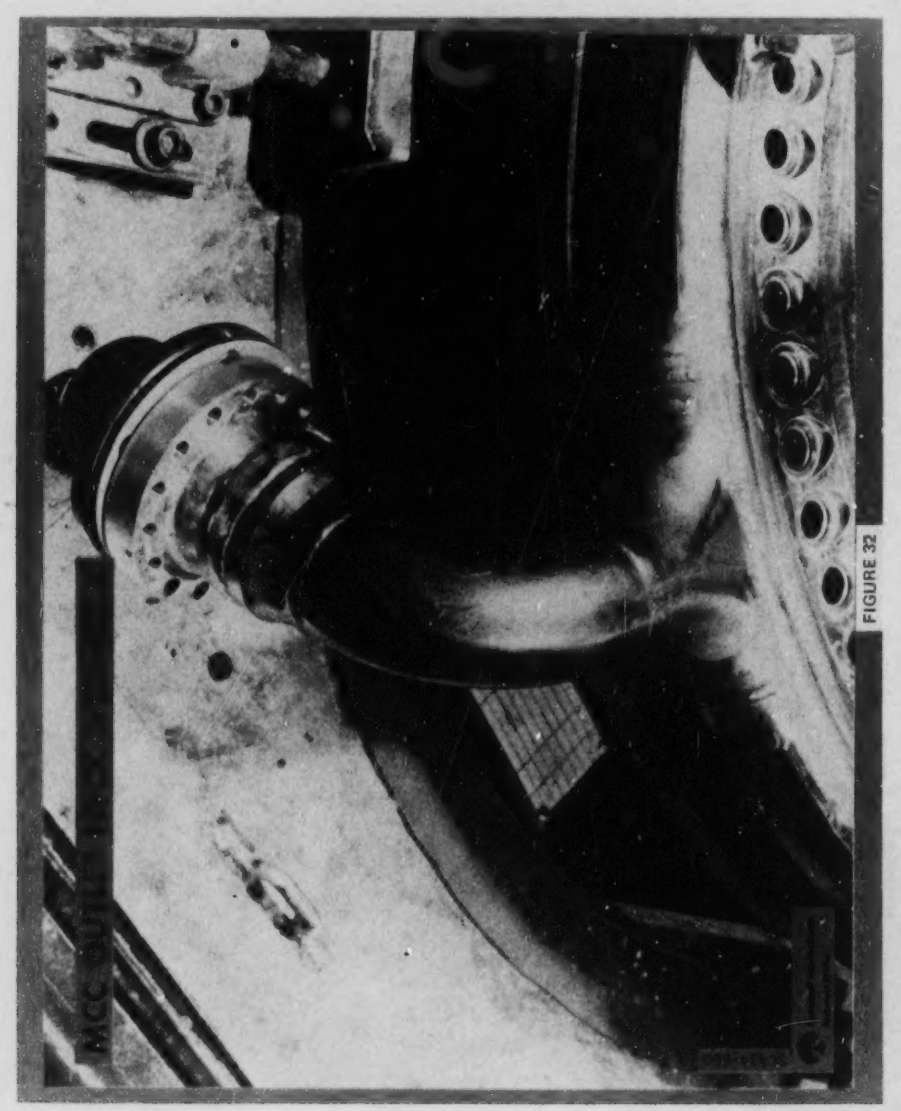


FIGURE 32

FIGURE 33

19-605 O—83——65

ENGINE 2011 MAIN COMBUSTION CHAMBER FABRICATION/HOT FIRE HISTORY

- MCC MADE IN STANDARD MANNER AND PROOF TESTED – OCTOBER 81
- DISCHARGE ELBOW DAMAGED IN FINAL MACHINE OPERATIONS
- DISCHARGE ELBOW REMOVED AND REPLACED IN ONE–OF–A– KIND REPAIR AND PROOF TESTED – APRIL 82
- TESTED IN ENGINE HOT FIRE ACCEPTANCE TESTS AND 2 FRF'S
  - 8 TESTS AND 850 SECS

1022

FIGURE 34

FIGURE 35

ENGINE 2011 MCC MANIFOLD FAILURE SCENARIO

- REPAIR PRODUCED MATERIAL OVERHEATING WHICH CAUSED:
  - COPPER PROTECTIVE COATING TEARS
  - REDUCED INCONEL 718 YIELD STRENGTH
  - HIGH RESIDUAL STRESSES IN 718
- PROOF TESTING DID NOT GENERATE SUFFICIENT STRESS TO CRACK INCO 718
  - ≈ 50 KSI PRESSURE STRESSES
  - NO H_2 ATTACK
  - VERIFIED BY TEST
- INCONEL 718 EXPOSED TO H_2 THROUGH COPPER TEARS DURING ACCEPTANCE TESTING
- HIGH RESIDUAL STRESSES PLUS OPERATING STRESSES ARE AT CRACK INITIATION LEVEL OF INCONEL 718 IN H_2

1024

FIGURE 36

ENGINE 2016

HEAT EXCHANGER LEAK

CHALLENGER ENGINES ACCEPTABILITY

- ALL OTHER MCC'S MANIFOLDS FABRICATED IN STANDARD MANUFACTURING METHOD
  - ≈ 982 TESTS AND 176,000 SECS WITH NO MANIFOLD CRACK
- RE–CHECKED MCC MANIFOLD X–RAYS FOUND NO DEFECTS
- BORESCOPED INTERNAL SURFACE MANIFOLD ELBOW – FOUND COPPER IN GOOD CONDITION
- MSFC/ROCKETDYNE RE–REVIEW OF ALL MR'S ON ALL 3 ENGINES TO IDENTIFY AND RE–ANALYZE (ECD 2–28)
  - ONE–OF–A–KIND REPAIRS
  - HARDWARE INVOLVED IN INCIDENTS
  - ANY OTHER SIGNIFICANT REWORK

FIGURE 37

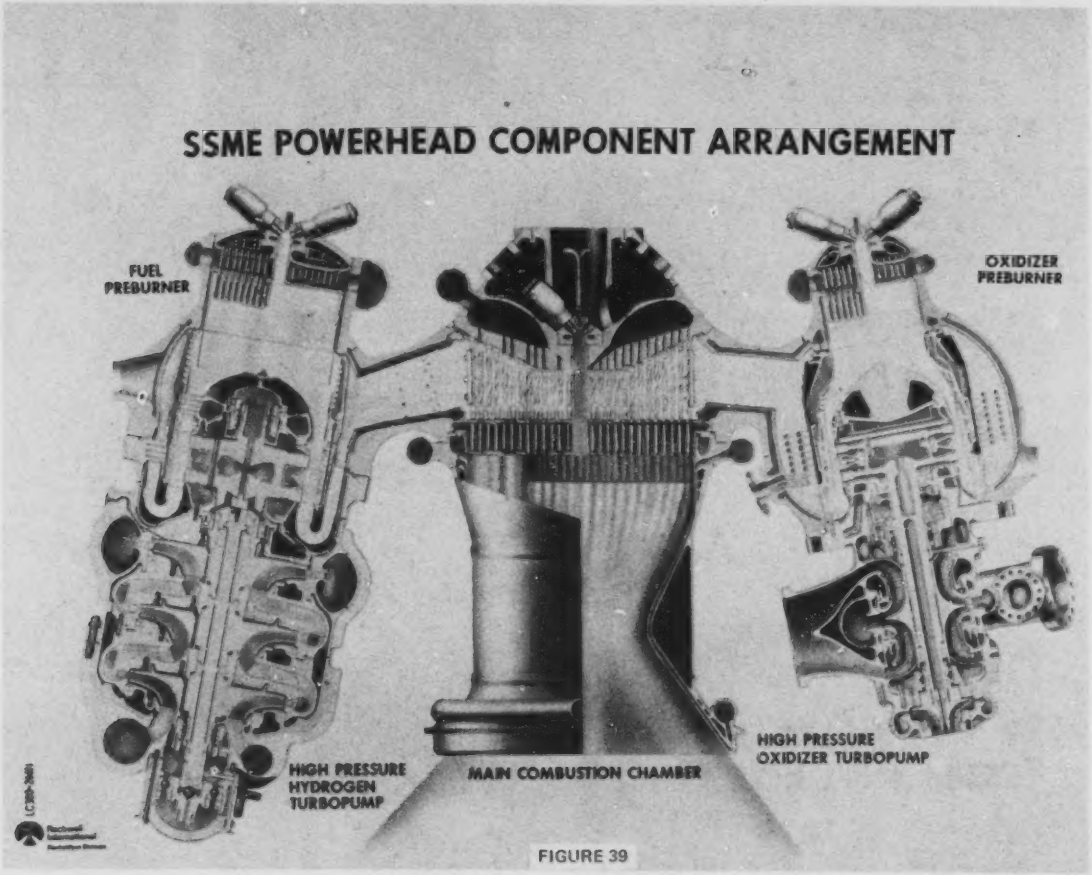

SSME POWERHEAD COMPONENT ARRANGEMENT
FUEL PREBURNER
OXIDIZER PREBURNER
HIGH PRESSURE HYDROGEN TURBOPUMP
MAIN COMBUSTION CHAMBER
HIGH PRESSURE OXIDIZER TURBOPUMP

FIGURE 39

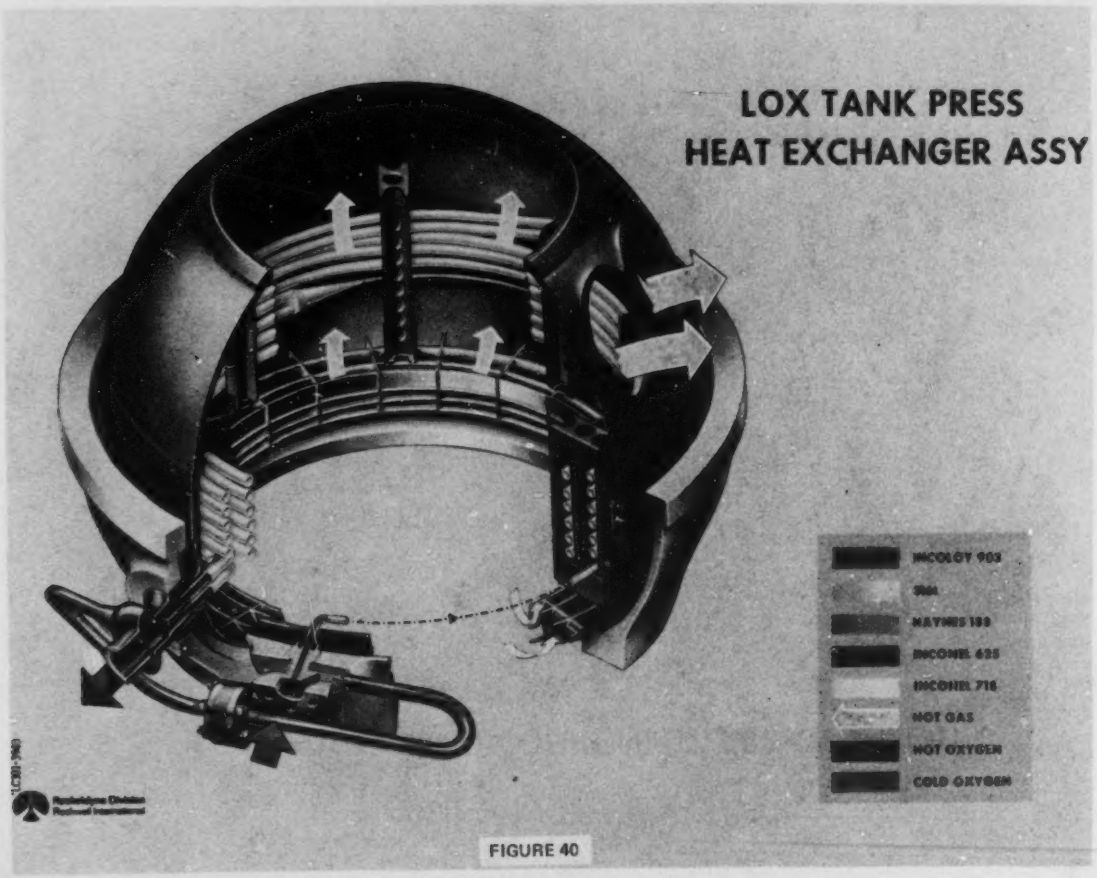

LOX TANK PRESS
HEAT EXCHANGER ASSY
INCOLOY 903
304
HAYNES 188
INCONEL 625
INCONEL 718
HOT GAS
HOT OXYGEN
COLD OXYGEN

FIGURE 40

ENGINE 2016 HEAT EXCHANGER FAB/TEST HISTORY

- HEAT EXCHANGER COIL PACK FABRICATED MAY 1977
- POWERHEAD WITH HEAT EXCHANGER EXPERIENCED TWO ENGINE INCIDENTS
  - ENGINE 0006 POWERHEAD FUEL SIDE INTERNAL BURNING (10–3–78)
  - ENGINE 0010 EXTERNAL BURNING (7–30–80)
- POWERHEAD USED IN ENGINE 2016
  - TOTAL INSPECTION AND RE–ASSESSMENT OF POWERHEAD
  - 931 SECONDS (ACCEPTANCE TEST)
  - MSLD TEST $< 2.4 \times 10^{-8}$

1029

FIGURE 41

POWERHEAD/HEAT EXCHANGER REASSESSMENT CONDUCTED

- INSPECTIONS/ANALYSES PRIOR TO USE IN ENGINE 2016
  - VISUAL EXAMINATION
  - THICKNESS MEASUREMENTS
  - HARDNESS MEASUREMENTS
- PARTS REPLACED
  - 2 PREBURNER INJECTORS
  - MAIN INJECTORS
  - EXTERNAL LINES
- PART REPAIRED SINCE NO SPARE AUTHORIZED FUNDED THROUGH JULY 1984
- HOT GAS MANIFOLD LONGEST LEAD TIME PART ON ENGINE
  - ≈ 3 YEARS TO POWERHEAD COMPLETION
- ORIGINAL DECISION MADE TO REPAIR AND USE POWERHEAD ON R&D ENGINE
- FLIGHT HARDWARE SHORTAGE RESULTED IN CHANGING ALLOCATION TO FLIGHT ENGINE

1030

FIGURE 42

ENGINE 2016 HEAT EXCHANGER LEAK TESTING

- HEAT EXCHANGER PASSED ALL REQUIRED TESTS PRIOR TO ENGINE DELIVERY TO KSC
  - MASS SPEC CHECK AFTER EVERY HOT FIRE TEST
    - ≈ 15 PSI VACUUM ON COIL AND HELIUM PURGE SURROUNDING COIL
    - 9 TESTS $< 2.4 \times 10^{-8}$ SCC/SEC LEAKAGE
  - 3200 PSI COIL PROOF TEST AND MASS SPEC TEST FOLLOWING EACH PUMP INSTALLATION
- AFTER DELIVERY TO KSC
  - OXIDIZER PUMP REPLACED
  - 3200 PSI COIL PROOF TEST CONDUCTED
  - COIL FAILED MASS SPEC TEST
    - 2×10^{-6} VS. 1×10^{-6} SPEC
  - FURTHER PROOF TESTING AND MASS SPEC CHECKS VERIFIED LEAKAGE

FIGURE 43

EXTERNAL TANK PROJECT

- CHARACTERISTICS
- PROJECT SUMMARY
- ACCOMPLISHMENTS
- FY 83 ACTIVITIES
- KEY PROJECT EMPHASES

FIGURE 48

ENGINE 2016 HEAT EXCHANGER FAILURE DETECTION

- TESTING AT KSC ISOLATED LEAK AT HEAT EXCHANGER INLET TUBE WELD
  - TUBE 0.190" ID AND 0.012" WALL THICKNESS
- APPARENT LACK OF FUSION VISIBLE BY INTERNAL TUBE BORESCOPE INSPECTION
- PART CUT–OUT AND RETURNED FOR METALLURGICAL ANALYSES
- LACK OF FUSION OCCURRED IN ORIGINAL WELD FABRICATION (1977)
  - VERIFIED BY METALLURGICAL ANALYSES

FIGURE 44

CHALLENGER ENGINES ACCEPTABILITY

- ALL CHALLENGER ENGINES PASSED RECENT PROOF AND MASS SPEC TEST
- ALL CHALLENGER ENGINE HEAT EXCHANGERS FABRICATED SINCE 1979
  - IMPROVED WELD PROCEDURES AND INSPECTION AND DOCUMENTED VERIFICATION
  - KEY IMPROVEMENT IN INSPECTION FOR WELD FUSION
- OPEN WORK
  - COMPLETE METALLURGICAL FAILURE ANALYSES
  - CONDUCT INTERNAL BORESCOPE INSPECTION OF WELD

FIGURE 45

SPACE SHUTTLE MAIN ENGINE
FY-83 ACTIVITIES

- SUPPORT STS–6 THRU STS–9 FLIGHTS
- COMPLETE FULL POWER LEVEL (FPL) CERTIFICATION
- INITIATE FLIGHT CERTIFICATION PROGRAM ORIENTED TOWARD DEMONSTRATING 55 STARTS – 7½ HOUR CAPABILITY
- ACCEPTANCE TESTING OF THE FOURTH FLIGHT SET OF ENGINES
- ACCEPTANCE TEST FIRST FLIGHT ENGINE TO GO THROUGH OVERHAUL PROGRAM (2109)

FIGURE 46

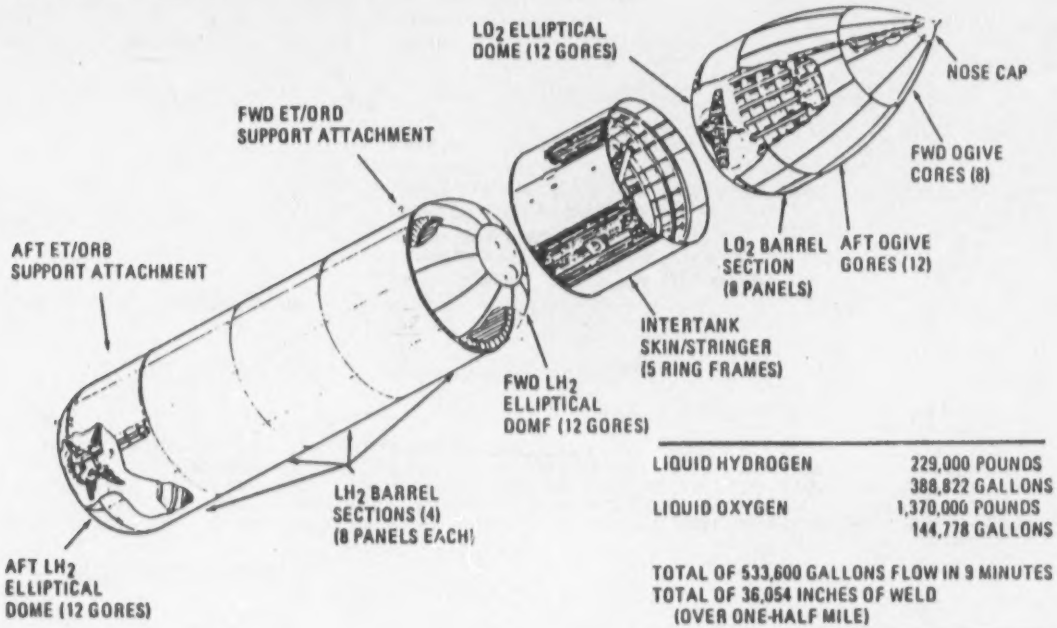
SPACE SHUTTLE MAIN ENGINE
KEY PROJECT EMPHASES

- FULL POWER LEVEL CERTIFICATION
- FLIGHT CERTIFICATION TEST SERIES
  - COST – ENGINE USES, SPARES AND MAINTENANCE REQUIREMENTS
  - RELIABILITY
- FLIGHT PROGRAM SUPPORT
  - ENGINE DELIVERIES
  - SPARE HARDWARE
  - SUSTAINING ENGINEERING
    - FLIGHT SUPPORT
    - ANOMALY RESOLUTION
    - FLIGHT READINESS

FIGURE 47

Space Shuttle External Tank

LENGTH	153.68 FT	(47 METERS)
DIAMETER	27.58 FT	(8.4 METERS)
LWT-1 SPEC WT	71,278 LB	(32,342 KILOGRAMS)
LWT-1 ACTUAL	66,824 LB	


LO_2 ELLIPTICAL DOME (12 GORES)
NOSE CAP
FWD ET/ORD SUPPORT ATTACHMENT
FWD OGIVE CORES (8)
AFT ET/ORB SUPPORT ATTACHMENT
LO_2 BARREL SECTION (8 PANELS)
AFT OGIVE GORES (12)
INTERTANK SKIN/STRINGER (5 RING FRAMES)
FWD LH_2 ELLIPTICAL DOME (12 GORES)
LH_2 BARREL SECTIONS (4) (8 PANELS EACH)
AFT LH_2 ELLIPTICAL DOME (12 GORES)

LIQUID HYDROGEN	229,000 POUNDS 388,822 GALLONS
LIQUID OXYGEN	1,370,000 POUNDS 144,778 GALLONS

TOTAL OF 533,600 GALLONS FLOW IN 9 MINUTES
TOTAL OF 36,054 INCHES OF WELD
(OVER ONE-HALF MILE)

FIGURE 49

EXTERNAL TANK (ET)

- **MARSHALL RESPONSIBILITY**

  RESEARCH AND DEVELOPMENT OF THE EXTERNAL TANK. THE EXTERNAL TANK CONTAINS LIQUID HYDROGEN AND OXYGEN FOR THE MAIN ENGINES; 1.5 MILLION POUNDS OF USABLE PROPELLANT AT LIFTOFF. THE EXTERNAL TANK IS THE STRUCTURAL BACKBONE OF THE SPACE SHUTTLE AND IS CONSTRUCTED OF ALUMINUM ALLOY SKINS WITH SUPPORT OR STABILITY FRAMES AS REQUIRED: SPRAY-ON FOAM INSULATION AND ABLATIVE MATERIALS ARE APPLIED FOR THERMAL PROTECTION.

- **PRIME CONTRACTOR** – MARTIN MARIETTA AEROSPACE

- **MAJOR SUBCONTRACTORS**
  - INTERTANK – AVCO
  - VENT VALVES – CONSOLIDATED CONTROL
  - FORMED PARTS (DOME GORES, OGIVES & CHORDS) AIRCRAFT HYDRO-FORMING
  - DOME TOOLING – BOEING COMPANY
  - LIQUID HYDROGEN/LIQUID OXYGEN TANK ASSEMBLY TOOLING – LTV CORPORATION
  - LH_2 BARREL PANELS–REYNOLDS

- **TEST FACILITIES**

  MARSHALL
  - LIQUID HYDROGEN STRUCTURAL
  - LIQUID OXYGEN MODAL
  - LIQUID OXYGEN STRUCTURAL
  - TPS DEVELOPMENT FACILITY

FIGURE 50

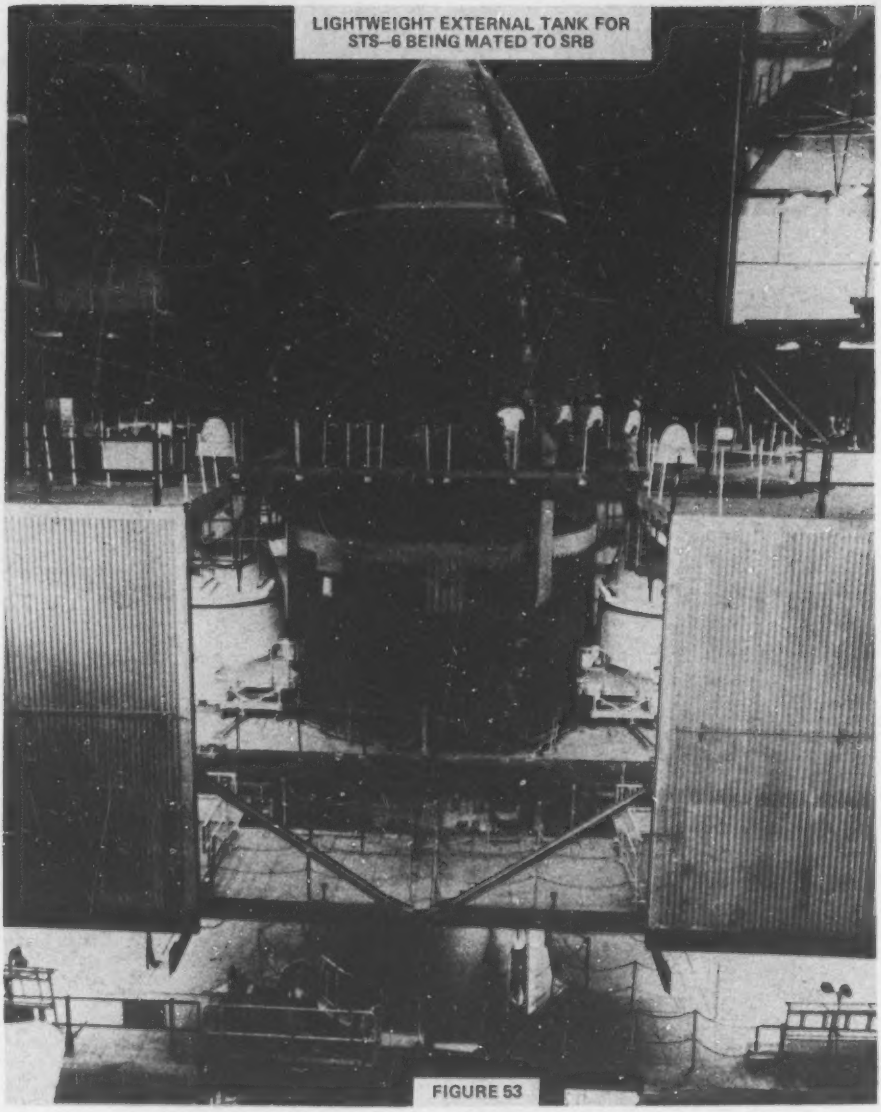


FIGURE 53

EXTERNAL TANK
PROJECT SUMMARY

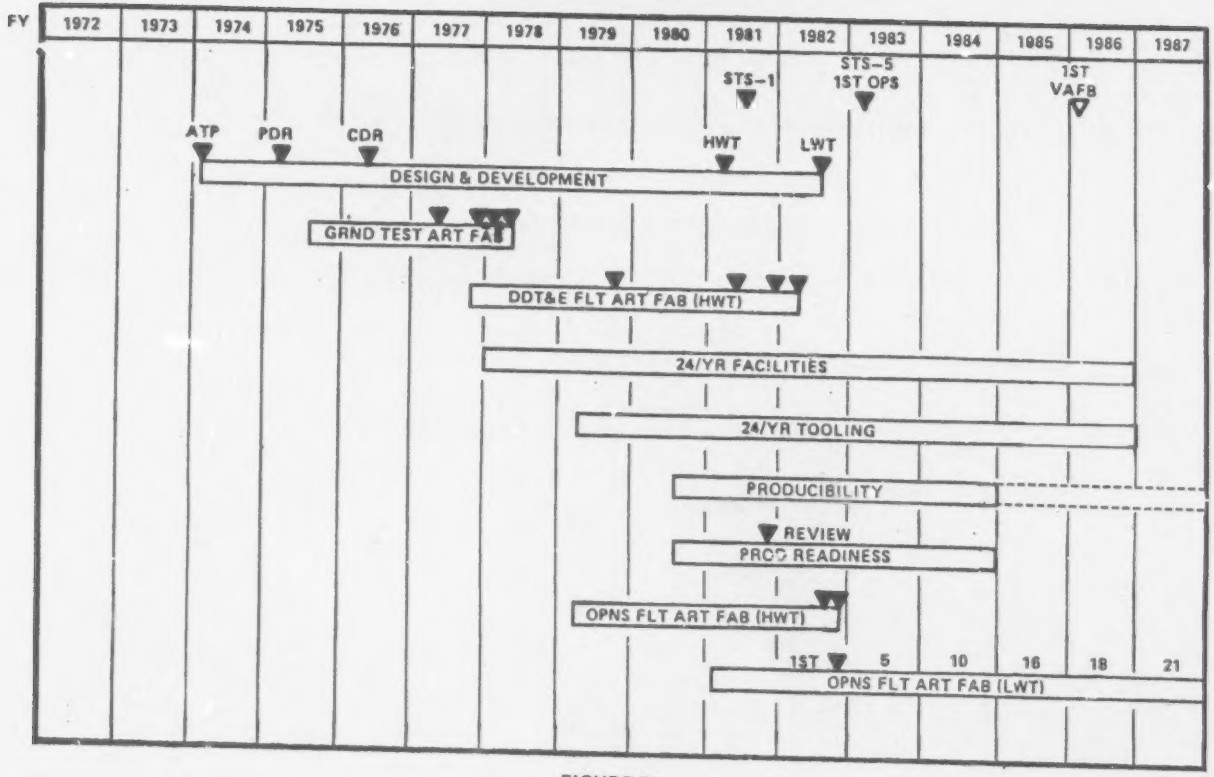


FIGURE 51

EXTERNAL TANK
ACCOMPLISHMENTS

DDT&E

- DEVELOPMENT PROGRAM NEARING COMPLETION
  SUCCESSFUL STS–1, 2, 3 AND 4 LAUNCHES
- REMOVAL OF DEVELOPMENT FLIGHT INSTRUMENTATION PROVIDED
  PAYLOAD INCREASE ≈ 2000 POUNDS
- LIGHTWEIGHT TANK REDESIGN – PROVIDES PAYLOAD INCREASE > 8000 POUNDS
  - DELIVERED TO KSC SEPTEMBER 15, 1982 FOR STS–6
  - ACTUAL WEIGHT LESS THAN SPECIFICATION WEIGHT
  - MANPOWER REQUIRED FOR FABRICATION LESS THAN PREDICTED

1040

FIGURE 52

EXTERNAL TANK
ACCOMPLISHMENTS (CONT'D)

- SUPPORT TO OPERATIONS
  - SUCCESSFUL STS-5 LAUNCH – (FIRST OPERATIONAL FLIGHT)
  - ET READY TO SUPPORT STS-6
  - ET-6 INSTALLED IN THE VAB FOR STS-7
  - ET-9 AT KSC FOR STS-8
  - PRODUCTION READINESS REVIEW CONDUCTED
  - TEN TANKS IN ASSEMBLY AT MAF
  - COMPONENTS UNDER CONTRACT THROUGH ET-22
    - INCENTIVE FEE PROVISIONS
  - PROPOSAL IN HAND FOR TANKS THROUGH ET-39

- INCREASED EFFORT ON PRODUCIBILITY IMPROVEMENTS AND PRODUCTION READINESS
  - PRODUCIBILITY TARGET SUBMITTED FOR APPROVAL – APPROXIMATELY 90% OF INITIAL $66M SAVING FOR 54 TANKS
- TOOLING TO SUPPORT 24 PER YEAR RATE ON SCHEDULE – AUTOMATED IMPROVEMENTS BEING INTRODUCED
- OPERATION OF MAF TRANSFERRED TO PRIME CONTRACTOR

FIGURE 54

ET–9 (STS–8) MOVE TO CHECKOUT

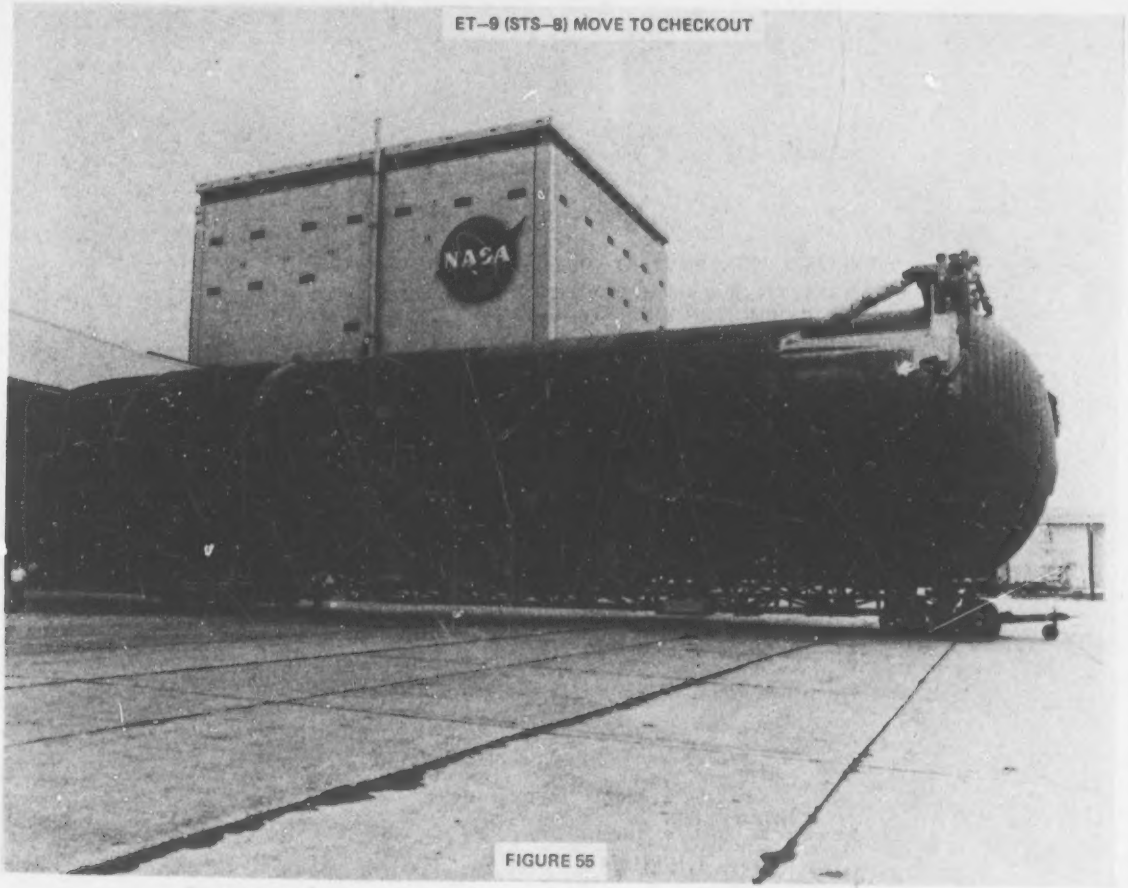


FIGURE 55

EXTERNAL TANK
FY-83 ACTIVITIES

- CAPABILITY DEVELOPMENT
  - CONTINUE ACTIVATION OF TOOLING TO SUPPORT RATE REQUIREMENTS
  - DEVELOP AND IMPLEMENT PRODUCIBILITY IMPROVEMENTS
  - CONTINUE PRODUCTION READINESS STUDY TASKS AND EVALUATION OF RECOMMENDATIONS

- SUPPORT TO OPERATIONS
  - COMPLETE ASSEMBLY AND DELIVERY OF FOUR EXTERNAL TANKS TO KSC
  - INITIATE SUBASSEMBLY OPERATIONS ON SIX TANKS
  - CONDUCT DELTA PRODUCTION READINESS REVIEW
  - CONTINUE PRODUCIBILITY/PRODUCTION READINESS ACTIVITIES TO ASSURE PRODUCTION CAPABILITY AND TO REDUCE UNIT COST
  - NEGOTIATE A BLOCK BUY OF TANKS ON A CPIF BASIS

FIGURE 56

EXTERNAL TANK
KEY PROJECT EMPHASES

- ATTAINMENT OF PRODUCTION RATE CAPABILITY
  - TOOLING
  - FACILITIES
  - PRODUCIBILITY
  - PRODUCTION READINESS
  - SUBCONTRACTORS
- COST REDUCTION
  - REQUIREMENTS
  - PRODUCIBILITY
  - INCENTIVE CONTRACTING – CPIF – FOR ALL DELIVERIES THROUGH FY–85
- SUSTAINING ENGINEERING
  - FLIGHT SUPPORT
  - ANOMALY RESOLUTION
  - FLIGHT READINESS

FIGURE 57

SHUTTLE SYSTEMS

- ACCOMPLISHMENTS
- MAIN PROPULSION TESTING
- KEY PROJECT EMPHASES

FIGURE 58

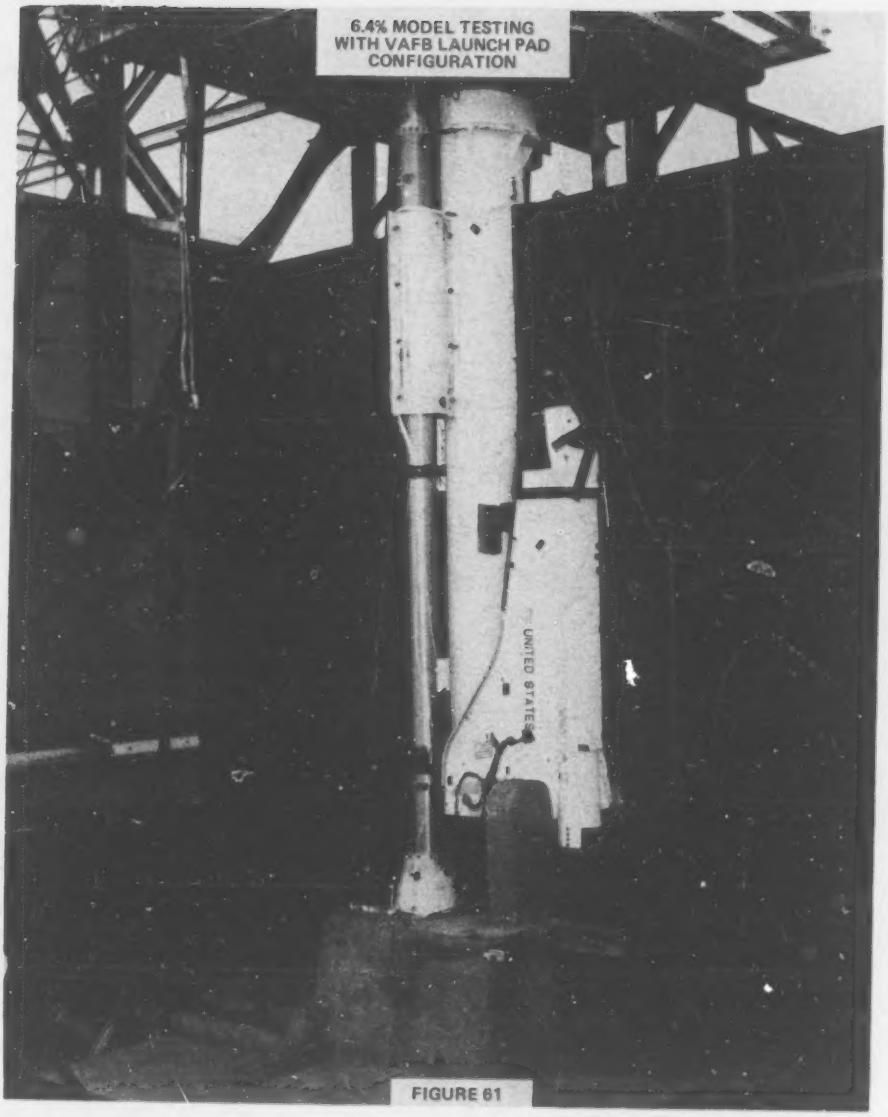

6.4% MODEL TESTING
WITH VAFB LAUNCH PAD
CONFIGURATION
UNITED STATES

FIGURE 61

SHUTTLE SYSTEMS

ACCOMPLISHMENTS

- SUCCESSFULLY SUPPORTED STS–3 THROUGH STS–5 LAUNCHES
  - MAIN PROPULSION SYSTEM
  - ASCENT FLIGHT SYSTEMS
  - HUNTSVILLE OPERATIONS SUPPORT CENTER (HOSC)
  - PRE–LAUNCH AND LAUNCH REQUIREMENTS
- OVERPRESSURE ASSOCIATED WITH VAFB LAUNCH PAD UNDER INVESTIGATION
  - ANALYSIS
  - 6.4% MODEL TESTING
- USAF ACTIVATION OF VANDENBERG AIR FORCE BASE (VAFB)
  - REVIEWED FACILITY DESIGNS
  - PROCURED COMMON SUPPORT EQUIPMENT

FIGURE 59

HUNTSVILLE OPERATIONS SUPPORT CENTER

FIGURE 60

SPACE SHUTTLE
MAIN PROPULSION TEST SETUP
AT NSTL

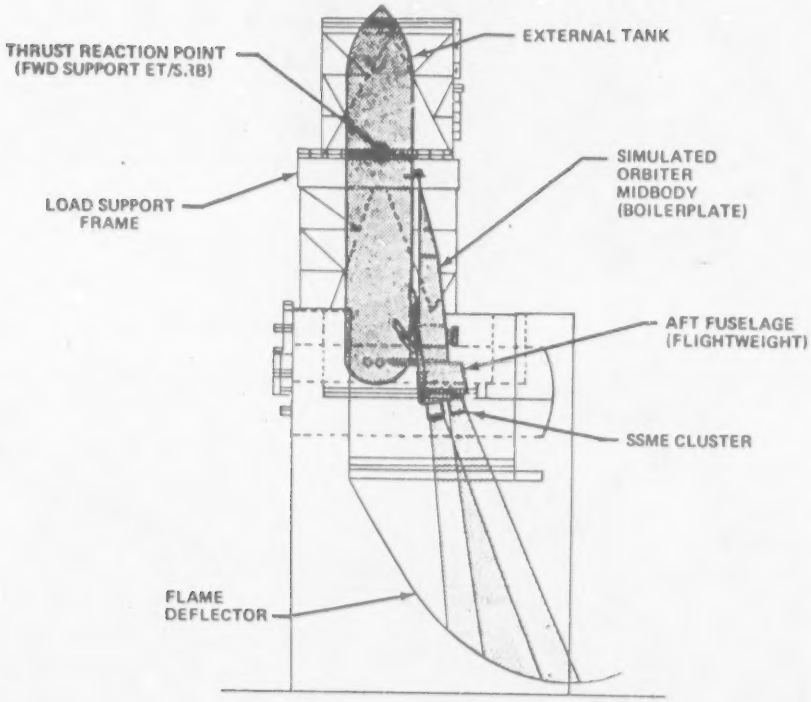


FIGURE 62

MAIN PROPULSION TEST (MPT)

- **MARSHALL RESPONSIBILITY**

  MANAGE AND DIRECT THE TEST PROGRAM. DEVELOP TEST FACILITY AND SUPPORT EQUIPMENT REQUIREMENTS.

- **CONTRACTORS**

  - PRIMARY – ROCKWELL INTERNATIONAL, SPACE SYSTEMS GROUP
  - SUPPORT – ROCKWELL INTERNATIONAL, ROCKETDYNE DIVISION
    – MARTIN MARIETTA

- **OBJECTIVES**

  DEMONSTRATE MAIN PROPULSION SYSTEM PERFORMANCE AND COMPATABILITY WITH INTERFACING ELEMENTS AND SUBSYSTEMS, INVESTIGATE OFF–NOMINAL CONDITIONS, AND VERIFY DESIGN.

- **HARDWARE CONFIGURATION**

  - ORBITER
    – FORWARD FUSELAGE – BOILERPLATE SIMULATOR
    – AFT FUSELAGE – FLIGHT CONFIGURATION
  - EXTERNAL TANK – FLIGHT CONFIGURATION
  - ENGINES – FLIGHT CONFIGURATION

FIGURE 63

MAIN PROPULSION TEST (MPT)
STATUS

- TEST OPERATIONS/PLANS
  - FIRST STATIC FIRING APRIL 21, 1978
  - LAST STATIC FIRING (SF–12) ACCOMPLISHED JANUARY 17, 1981
  - ONE ADDITIONAL FIRING PLANNED FOR EARLY MAY 1983 TO VERIFY PROPULSION SYSTEM FOR 109% RATED POWER LEVEL CAPABILITY
    - UNDER REVIEW
    - PROBLEM WITH ENGINE AVAILABILITY

1052

FIGURE 64

STATEMENT BY DR. FRED A. SPEER, MANAGER, SPACE TELESCOPE PROJECT, SPACE TELESCOPE PROJECT OFFICE, MARSHALL SPACE FLIGHT CENTER

Dr. SPEER. Chairman Volkmer, Representative Lujan, Representative Flippo, I would like to present to you the space telescope project. Figure 1 is an artist's concept of the major elements of the project. You can see the spacecraft pointing at an object of interest. It will communicate at the same time with the tracking satellite that will be launched on our next shuttle flight. The satellite, in turn, radios the information down to the ground station at White Sands, and from there to the Control Center at Goddard, which in turn communicates with the Science Institute now under construction at Johns Hopkins University. We are taking full advantage of the shuttle in several ways. First of all, transportation to orbit is provided by the shuttle; then, we deploy the telescope, once we have reached the satisfactory altitude, out of the shuttle by the remote manipulator system. After release of the telescope, the shuttle will remain in a very close orbit until all systems are working and checked out. We will then continue to support the telescope through refurbishment with the shuttle which would provide maintenance support in orbit. Should it become necessary to return the telescope to the ground for more extensive refurbishment, the systems are designed in such a way that we can retrieve it and return it to the ground again with the shuttle.

Representative LUJAN. Will it be in synchronous orbit?

Dr. SPEER. No; it will be at an altitude of 320 nautical miles.

The agency considers this the most important science project ever undertaken and this illustration [fig. 2] may indicate to you why we feel that way. Observations from the ground, of course, are obscured by the atmosphere that surrounds the Earth. It limits the sharpness of the pictures and constrains the spectral ranges that we can observe. For instance, ultraviolet and infrared radiation cannot penetrate the atmosphere. You have to go outside the atmosphere, and the space telescope as shown here is in low Earth orbit at 320 nautical miles. Of course, once it is launched, it will slowly come back down, and we will have to from time to time, boost it up again to a satisfactory altitude. Man can see into space with his own eyes for a distance that is on the order of 600,000 light years. So, as long as stars are within that distance, you don't need anything. Our biggest and best ground-based telescopes can get you to a 2 billion light year distance. And the tremendous increase in observing volume is shown by this larger radius that increases the volume of space under observation 350 times.

Representative LUJAN. Which other observatory are you talking about? Is it Arecibo?

Dr. SPEER. No; I'm talking about Palomar Mountain and the Chile observatory.

We will be able to see very faint stars. The pictures will be 10 times sharper than any accomplished before because we will see objects that are 50 times fainter. In fact, if you look at the distance here in terms of light years, we can go to 14 billion light years. There are theories that say the total age of the universe is on the order of 20–21 billion years, so we can almost see to the edge of the

universe. This is a tremendous advancement in the state-of-the-art of astronomy that we can expect from the telescope.

Representative LUJAN. Excuse me, I asked a question a moment ago about Arecibo. Is this a different kind of telescope than the one at Arecibo?

Dr. SPEER. That one is a radio telescope. The space telescope is an optical telescope, sensitive in infrared to the millimeter range; it will go to Lyman alpha in the ultraviolet where the spectral range is much greater than we can see with our own eyes.

Figure 3 is a diagram of the space telescope. Let me use it to explain some of the main features. The interior is taken up by what we call the optical telescope assembly that carries the primary mirror and the secondary mirror. The light baffles prevent any stray light from getting where it shouldn't go. The reflected light will eventually wind up in one of the instruments that are arranged as—four axial instruments, one radial instrument, and three fine guidance sensors. They all share the focal plane of the telescope without any rotations or any movements.

Representative FLIPPO. Dr. Speer, you say it's a great importance that the Agency puts on this. Could you put the complexity of this thing in context for us? It looks like a very complex piece of equipment. What are some of the breakthroughs that you've made to be able to accomplish this?

Dr. SPEER. The major advance in the state of astronomy will be accomplished in several ways. First, the primary mirror has to be extremely well ground, polished, and coated to a degree that has never been done before. The surface is very close to the design, within one-sixtieth of a wavelength. Second, we want to assure that the distance between the primary mirror and the second mirror does not vary by more than a very small fraction of an inch. The exact distance can only be maintained, at all temperatures, if we use graphite epoxy structures on a very large scale. Third, we have a pointing control system that will point to a star or to a stellar object within one-tenth of an arc second. As part of the pointing system we have a very tight stability requirement. In other words, the space telescope has to remain quiet and extremely stable in order to retain this orientation within 7 milliarc seconds. These are, in a nutshell, the most demanding requirements; and, as I will explain later, these various parts contribute to satisfy these requirements. They are all done in different phases by different contractors. That makes up for the complexity that you mentioned.

Dr. LUCAS. Fred, could you use some examples to explain what an arc second pointing means?

Dr. SPEER. I mentioned the stability requirements of 7 milliarc seconds. This equates to being able to sight on a dime at a distance from Washington to Boston. This is a fantastic accuracy requirement, and you can see why we want to operate the telescope away from man. Even a man breathing or moving his arm would upset the required stability. We are even worried about possible instability caused by moving mechanisms in some of the instruments. They have to be treated very specially in order not to upset the stability of the space telescope.

Chairman VOLKMER. Is the requirement for the accuracy because of the distance from the objects that you are going to be viewing?

Dr. SPEER. We set ourselves a target to improve pointing accuracy by an order of magnitude over what we can accomplish on the ground. It is consistent with the elimination of the atmospheric perturbations to now go to what we call a diffraction limited system. The only physical limitation that we have now is the diffraction that goes with any kind of optical system. We don't have to worry about imperfection of the mirror. We don't have to worry about the stability.

Chairman VOLKMER. I'll turn my question around. Why is it required that we have this much accuracy?

Dr. SPEER. Absence of an atmosphere, the quality and size of the mirror, the dimness of the star that we want to discover, all meet together in establishing these requirements. If one of these requirements that I mentioned would be much less, than the rest of the system wouldn't really perform in an acceptable way. I take your question to mean, if we have a very good mirror but do not have the stability accuracy that I mentioned, then we would have a mirror that was too good for the overall mission.

Dr. LUCAS. Fred, couldn't we explain it like this? If you had a dime mounted on the wall, and you were shooting at it with a rifle, you'd have a little bit more flexibility in your sighting than if the dime were in downtown Huntsville, a few miles away. I think that's what accounts for the requirement, you're looking over such a great distance with the space telescope.

Chairman VOLKMER. If you weren't trying to go as far in space, you wouldn't have to have as much accuracy.

Dr. SPEER. The solar arrays will provide the electrical power required, and the high gain antennas are used for contacting the tracking satellite, and you can see the low gain antennas that are also being used for communications with the tracking satellite.

I will now explain the organizations involved in the project (fig. 4). The project is being managed by the Marshall Space Flight Center. We are responsible for project management as well as orbital maintenance. We are supported by three NASA centers, by the European Space Agency, and by two major associate contractors. Lockheed is responsible for the systems engineering and integration for the entire space telescope. They are, in addition, responsible for the design and manufacture of the outer structure of the telescope, including the equipment section which contains all major equipment needed for the telescope—batteries, data systems, thermal control, and so on. They are also responsible for the assembly and verification of the telescope. Each instrument plus the optical telescope assembly, the solar arrays are coming as single units to Lockheed. Lockheed is responsible for assembling the whole space telescope. They are also responsible for assisting the Kennedy Space Center during and after the launch and the orbital verification. This launch will be very similar to other shuttle launch activities. The orbital verification is a period of about a month following launch to allow checkout of all systems before we can turn it over to the science people to begin their observations.

Perkin-Elmer, at Danbury, Conn., is responsible for development of the optical telescope assembly, including the mirrors that I mentioned. They are responsible for the systems engineering of the focal plane assembly. The focal plane assembly is this lower por-

tion including the provisions to hold the instruments and the fine guidance sensor, and they are responsible for this very important part of the pointing control system which we call the fine guidance sensor.

Goddard Space Flight Center is responsible for the development of all scientific instruments. We have five, one of which is being provided by the European Space Agency; it is one of these axial ones. Goddard is responsible for the command and data handling unit that goes to these five instruments. That Center is also responsible for building and operating the control center located at Goddard that will control the space telescope in orbit, and Goddard is also managing the Science Institute that is under construction now at Johns Hopkins University.

Johnson Space Center is responsible for the crew interfaces and all preparations for launch that will involve the shuttle interface, and the interface with the crew on maintenance and refurbishment missions.

The Kennedy Space Center, of course, has its traditional role for the launch operations and is responsible for providing the facilities for the checkout and moving to the pad and launch.

I mentioned that the faint object camera is one of the European Space Agency provided instruments. The solar array is in manufacturing and checkout right now in Bristol, England and the last item refers to their participation in the Science Institute. They have agreed to participate with some 15 people in the operations of the Science Institute once the observatory is launched.

Representative LUJAN. Things are spread so far using the space telescope. For example, the tracking satellite will transmit data to White Sands. White Sands will transmit it over to Goddard, and Goddard will send it over to Johns Hopkins. I am not making a pitch for building it at White Sands because it happens to be in my home State, but why do you have to go through all that? Why couldn't it be in White Sands.

Dr. SPEER. The tracking satellite is a common user system. It's a tool for all payloads, not just space telescope. We will have to share. We need two ground stations to work with the tracking satellite and each project has an optimum location for its own operations system. In this particular case, Goddard has had a traditional role in controlling the scientific satellites of the past, and they have facilities that are needed for that special computer base. It was felt that this was an optimum choice. Now, you are right in the sense that one could have placed the Science Institute at the Goddard Space Flight Center and removed that last link. But, I think it is, in fact, the first time we are doing it this way, and the scientists that work on the space telescope feel that they want to really have their own Science Institute to run the mission and to be fairly independent of what you might call programmatic influences that might have existed at other locations. So, they insisted early in the formative stages of the project on having a place of their own. NASA, I think is very much in agreement with this support; we want to use it as a testing ground on how to run future scientific missions. Don't forget the space telescope will have international participation from all countries, not only from ESA, which participated financially. They, of course, have a certain built-in

birthright for some portion of the observations. But, we are inviting the total international participation. So, I think there was merit in putting this on the campus of a university partly to take advantage of Johns Hopkins University astronomy department and to make this truly a scientific endeavor. The control center at Goddard primarily functions as the operations center to take care of the operational needs of the telescope from a technical point of view, but not to perform scientific operations. Scientific operations will reside at Johns Hopkins.

Figure 5 shows the present status of the optical telescope assembly. This is a picture of the 2.4-meter mirror [fig. 6]. You can see the tremendous size. The center is covered with a metal plate that will be removed and the mirror will receive the central baffle. You see here, better than in later pictures, the three holes in the mirror that will be used to support the mirror to the rest of the structure with three axial links that connect to the main ring. There are three additional tangential links, and I will point them out in a later picture.

Chairman VOLKMER. The mirror is of glass composition?

Dr. SPEER. This is an egg crate design of a glass mirror that is 2.4 meter diameter, coated with aluminum, with a magnesium fluoride overcoat.

Dr. LUCAS. It is a special glass with a very low coefficient of thermal expansion.

Dr. SPEER. The second item here refers to the major structural elements that have now all been completed and are on hand [fig. 7]. The figure shows the graphite epoxy metering truss that maintains a very precise distance between the titanium main ring that is shown here, and the fixture that will eventually hold the secondary mirror. The distance between these points has to be kept very stable and that is the job of this metering truss. As shown in this configuration, a test was preformed that provided us with the response of this large structure to dynamic excitation so that we can put into our mathematical model the exact manner in which this structure responds to vibrations. This is very important for the design of the control system.

Representative LUJAN. Where will it all be finally assembled?

Dr. SPEER. It is now in the very early stages of the final assembly at Perkin-Elmer, and once the optical telescope assembly is completed, it will be shipped to Lockheed and the rest of the assembly will take place there.

This is another part of the major structure, the focal plane structure [fig. 8]. These bays are going to retain the four axial instruments. The bays underneath will accept the three fine guidance sensors and the wide field/planetary camera. During testing, we had a fairly major failure in the flexures that connect the focal plane structure with the main ring. This was one of our significant problems we had last year. It simply meant that these flexures are not strong enough to sustain the lift-off load of the shuttle during launch. We had to find a solution to solve that problem without giving up the thermal and structural rigidity characteristics of the graphite epoxy structure. We show you on the next photo how we did this [fig. 9]. We added to the outside of the flexures that you just saw on both sides, titanium structures, we call them boots,

that are bolted to the graphite epoxy flexures and at the same time bolted to the main ring. These provide additional load carrying capability and we have tested these, and they are satisfactory. So, we have solved that problem.

Figure 10 is a fairly recent picture. You asked where the assembly of the optical telescope would take place. This was done at Perkin-Elmer and the photo shows the process of lifting the primary mirror, which you see here from the back side. You can see the construction of the mirror fairly well, the egg crate design. All these are hollow cubes and the mirror is on the other side. This is a picture of the setup that will permit the mirror to be placed inside the main ring. These are the saddles that will carry the tangential links to the main ring.

Also shown is the main ring titanium structure which is now completely covered with heater pads that will provide thermostatic control that will keep the main ring always at the same temperature or within a narrow range. This particular activity has given us quite a bit of a problem and it was really the first major step that Perkin-Elmer had to perform in the assembly of the telescope. Due to several problems with the saddle, which turned out to be very marginal in its thickness and problems with the way it was bonded to the backside of the mirror, we were delayed in our first steps of the assembly. We are now significantly behind our integration schedule. It must be realized that we are dealing with flight hardware, and everything has to be done very, very carefully. Any wrong movement could damage or even destroy the mirror. So, we have to go through exercises with some simulation hardware in order to show that it would be safe. This, and the problems that I mentioned, have brought us into a position that we are now significantly behind schedule.

Chairman VOLKMER. Have those been overcome yet?

Dr. SPEER. The problems have been overcome. But, we do not really see a good way to catch up, to accelerate the schedule now to a point that we could come back to the original schedule. We have lost time, probably irretrievable.

This is a major piece of ground support equipment [fig. 11], which is another area where Perkin-Elmer has somewhat underestimated the complexity of the job. You see this very solid stainless steel ring which simulates the spacecraft. Eventually the optical telescope assembly (OTA) will be put into the support systems module at Lockheed. While at Perkin-Elmer, they are using this ring to serve in its stead to carry the OTA. We are able to rotate it, lift it, and this is the dolly that will do all that. These two major items have now been completed, but there is still a lot more special test equipment and ground support equipment which is not completed.

I want to talk for a minute about how we transport all these huge items. We need to fly the optical telescope assembly from Perkin-Elmer to Lockheed at Sunnyvale; and it turned out to be fairly expensive job to build a good transportation canister for this. So, we searched our inventory and found the old Apollo telescope mount (ATM) container from skylab days, and we are in the process now, with the help of a local contractor, of enlarging this ATM container [fig. 12]. The interface to the Guppy aircraft is the same,

and we will be able to fly the OTA on the Super Guppy, pretty much the same way as we flew the ATM, from here to Lockheed. For the transportation of the space teleschope as a total spacecraft, this container will be too small. We need a larger one, and we have agreed with Kennedy to use one of their payload canisters. They will have two at the time we launch, and we will use one of their payload canisters.

Chairman VOLKMER. Will you be able to use the Guppy on that then?

Dr. SPEER. No, unfortunately, there is no airplane big enough to do that. We have to do this on a ship.

Representative LUJAN. How can you get it into the shuttle if you can't get into the Guppy?

Dr. SPEER. The Guppy is too short. Even if the Guppy was long enough, the weight of this payload is 25,500 pounds and would require an excessive number of stops. So, we have concluded, after considerable study, that the best way at this time would be to ship it by military sealift.

Represenative LUJAN. Is the Guppy smaller than the payload bay of the shuttle?

Dr. SPEER. It is shorter. It could carry the weight, but only for very short distances.

Represenative LUJAN. Will you truck it or ship it by water?

Dr. SPEER. By water. For that reason it is very important that we have this payload canister because the environmental control provides an ideal environmental for the ST during its long journey. It takes more than 1 month to get from Lockheed to the Cape.

I talked about the delay in the primary mirror assembly which was due to a number of technical problems and I should also say that Perkin-Elmer was not able to predict with sufficient realism what it really takes to do that [fig. 13]. The fine guidance sensor has run into assembly problems. There is the problem of alinement and putting these very delicate systems together. they had a number of problems that had to be resolved, each taking some extra time. We had the problem with the focal plane structure and had to put titanium boots on; manufacture them and put them on. I also touched on the need for some additional special test equipment that only now has become known as being required. The total sum of this is putting us into a difficult position at the present time. We cannot, I believe, hold onto the original delivery schedule of the optical telescope assembly from Perkin-Elmer to Lockheed, which was December of this year, December 1983. It will be considerably downstream. But, I really don't see much of an opportunity to catch up again because the job in front of us is just as complex as the one that we have behind us.

We do need to improve the management systems, particularly at Perkin-Elmer and I'm showing you here the corrective actions that have been taken. We want to be closer to where the action is, so I have moved the entire optical telescope assembly project office to Perkin-Elmer to shorten the communication lines and to make sure that we can take corrective actions as required. We have, as a consequence of this delay and its impact on the other project elements, to rebalance our program resources. This activity is now underway, but it is not yet completed. As soon as we review Perkin-

SHUTTLE SYSTEMS

KEY PROJECT EMPHASES

- CONTINUE MAIN PROPULSION SYSTEM AND ASCENT FLIGHT SYSTEM ENGINEERING ANALYSIS AND INTEGRATION
- PROVIDE LAUNCH SUPPORT
- SUPPORT THE ACTIVATION OF VANDENBERG AIR FORCE BASE (VAFB)
  - REVIEW FACILITIES, GROUND SUPPORT EQUIPMENT AND VEHICLE FLOW
  - PROCURE COMMON GROUND SUPPORT EQUIPMENT
  - OVERPRESSURE AND ACOUSTIC TESTING ASSOCIATED WITH THE VAFB LAUNCH PAD CONFIGURATION
- MAIN PROPULSION TEST
  - STATIC FIRING SCHEDULED EARLY MAY 1983 TO VERIFY PROPULSION SYSTEM AT 109% POWER LEVEL
- FLIGHT EVALUATION/READINESS ASSESSMENTS

FIGURE 65

SUMMARY

- PROGRESS EXCELLENT WITH EXCEPTION OF COMPLETING SSME CERTIFICATION AT 109% THRUST
- TECHNICAL PERFORMANCE AND PRODUCTION CAPABILITY EVIDENCED WILL SUPPORT SPACE SHUTTLE OPERATIONAL MISSIONS
- PROGRAMS IN PLACE TO IMPROVE OPERATIONAL EFFECTIVENESS
  - IMPROVE PAYLOAD CAPABILITY
  - REDUCE COST
  - SIMPLIFY LAUNCH SITE OPERATIONS
  - ADDITIONAL SRB AND SSME HARDWARE IN PROCUREMENT

FIGURE 66

Elmer's proposed new schedule, we will have to begin with this activity and then report back to NASA Headquarters and in turn to Congress.

Representative LUJAN. Have those been mostly management problems or technology?

Dr. SPEER. It's both. I think it's a combination of the two. We certainly had a number of technical problems. We certainly have not had the kind of forceful management that you would need for this most difficult job. It is unfortunate that the most difficult job of this project was given to a contractor who was not strong enough from a management point of view. There also was simply an underestimation of the effort which, of course, is another indication of poor management. They did not have the ability to tell us early enough what is really required to do the various steps. As we went through preliminary design, manufacturing, and now entering the assembly phase of the program, preliminary design was on schedule, manufacturing was still behind but more of less acceptable. But now, as we enter assembly, we have this very major setback on the primary mirror assembly, which makes us take these steps.

Now, Perkin-Elmer, I would have to say, has fully agreed with our assessment. They are taking very forceful actions. They have put in a new program manager, who has some background in other programs, in whom we have confidence. Corporate management has moved in very forcefully. The executive vice president of the corporation is taking charge of this optical group right now. He will eventually put anothier man into that, but right now he is handling it himself. That's Gaynor Kelley. They have increased their manpower in order to not fall far behind schedule, and that manpower is now showing results. In addition we have given quite a bit of help from this center, forced Perkin-Elmer to do a more detailed indepth schedule penetration. In other words, we required them to look at each single drawing, each single operations sequence which is required to proceed. We expect the OTA delivery to be late, how much late, of course, is a function of replanning and that we will work out in the next couple of weeks.

Chairman VOLKMER. Fred, a question I have. Perkin-Elmer made their proposal. You all reviewed that in all aspects. You didn't foresee any problems in the total manufacturing assembly in their proposal?

Dr. SPEER. We did foresee a number of difficulties. We had our own assessment, our own cost models that indicated, at that time, that the cost would be higher than the contractor proposed. We also knew, even at that time, that there would be some additional requirements that, for consideration of time, were not put in the original Statement of Work, and for all these reasons there was a reserve set aside to deal with these problems. Unfortunately, this reserve was not sufficient. In other words, the complexity, the difficulty of the job, was still somewhat greater than expected. The contractor proposal, the initial contract usually does not take all points into consideration that we plan for and budget for. We did not foresee the degree of current difficulties of assembly.

Representative FLIPPO. Dr. Speer, what levels of reserves were set aside?

Dr. SPEER. We had, I believe, almost 50 percent of the contract value, at that time, in reserve.

Representative FLIPPO. Were there a great many changes in requirement in specifications?

Dr. SPEER. No, Representative Flippo. I believe that the requirement changes that we imposed on both Perkin-Elmer and Lockeed were very small, limited to make-work changes, and did not contribute significantly to the large cost increases. Cost was primarily driven by what we call cost growth. That is, inscope changes a contractor has to make in order to fulfill contractural obligations; to some extent by technical problems that we ran into, and by general inflation and overhead rate increases that exceeded our planning estimate.

Representative FLIPPO. It's interesting to know the Hearth study that looked at some of the reasons for cost that eventually exceeded estimates were changes in the requirements and that sort of thing, and not well understood on the front end. Here's an area that was studied quite extensively and the cost overruns are not exactly like the Hearth study generally indicates. If you compare to this, say to the shuttle development cost, the engine situation in particular. There is a situation that you did have changes in the structure and the requirements. In other words, you go from 100 to a 109. And, also I thought it was a really interesting thing. It looks to me like a lot of those engine problems were the result of using test parts, and that sort of thing. It seems like the entire engine development program was short on spares from the day one, and inadequate funding. Is that a fair characterization, Bob?

Mr. LINDSTROM. That is true, Representative Flippo.

Representative FLIPPO. But the shuttle cost overrun of those engines might have been due to changes in specifications. But, that's not true in this instance, is it.

Dr. SPEER. I'm not sure I'm familiar enough with the nature of all the shuttle changes, but in this particular case I think we are dealing to some extent with a better understanding of the requirements.

Representative FLIPPO. I guess one of the things that you can say about these two projects whose costs are over: one may come from changes in requirements, and another may not. But, there's one thing that's for certain, they are both development projects that have never been done before. And when you are engaged in that kind of business you're going to have some costs that exceed what you thought it was to begin with. We're talking about the shuttle being operational. It looks to me like these very problems that we're facing now would bring me to question whether or not we are in an operational situation with the shuttle. I guess we can expect any time you develop programs of this magnitude that you are always going to encounter things that you are not able to predict.

Representative LUJAN. It seems, from all this conversation, to me that probably the contractor is capable in doing the work but just didn't have the management skills to have it all come together at the same time. It's like the expression that you have a marching army going on in all these different areas and it just wouldn't come together.

Dr. SPEER. That's part of the answer, and the other part is that we are in a very advanced development effort. We had to redesign the fine guidance system because it was too complicated and could not be built. The change of the focal plane structure from a titanium to a graphite epoxy was done after various thermal analyses had shown that titanium would not satisfy the technical requirements. We have more recently found that contamination control is important to observe the ultraviolet spectrum. We have to bakeout, in a vacuum chamber, all structures in order to prevent molecular contamination. I am not trying to apologize, but some of these requirements are not easily foreseen when you award a development contract.

Chairman VOLKMER. At the time the contract was let back in 1977, there were things that were not anticipated in the technical aspects?

Dr. SPEER. That's right.

Representative LUJAN. Looking back to other contractors that bid, would they have had the same problems?

Dr. SPEER. The only other that bid was Kodak. And they came in a little higher but not a lot higher than Perkin-Elmer.

Chairman VOLKMER. Would you say today that they are a little more realistic in their anticipated costs?

Dr. SPEER. Yes, I would.

Dr. LUCAS. You don't have a lot of choice in contractors for this kind of activity; only about three.

Chairman VOLKMER. As I understand your presentation of where we are on the telescope, putting additional funds into the program isn't going to help with the making up for the delays.

Dr. SPEER. We are going to have to reschedule the activity. We had planned for a first half of 1985 launch date and that will change as a result of these problems at Perkin-Elmer. Again, that requires some iterative process, and we need to find out how much more money can be made available in 1983. In this fiscal year, we need to do the reprograming within the Agency, and, depending on that, arrive at a new schedule and cost.

Chairman VOLKMER. When will you know that?

Dr. SPEER. Within a month.

Representative LUJAN. Talking about additional funding. Supposing additional funding could get it done in late 1983 as opposed to early 1984? What advantage would there to be launching in late 1983?

Dr. SPEER. If there was a way to recapture the time lost, which I do not believe there is, and I will explain in a minute why, the main advantage for doing that would be to reduce the total runout cost of the project because we do not have the cost of the marching army. Now, the reason I say that probably is not possible is that we are now entering a phase in the program where only a few people can work on mainstream assembly at a time. We are limited by skills. We need very special optical technicians that are not readily available for much of the remaining work. Perkin-Elmer has committed to adding 10 to 20 of their specialists per month in the next 2 months. And that is very difficult to do. I am not completely convinced that they can do that. Our assessment has to be a little more realistic. The experience we have with Perkin-Elmer's past

performance indicates that we have to carefully assess their estimates to assure that there is no overoptimism.

I'd like now to change to the Lockheed activities [fig. 14]. As you can see, here is the heart of their contribution or what we call the support systems module which is a very large unit [fig. 15]. It will include all the various components, which we call black boxes, the electronics, the batteries, the elements of the pointing control system and the like. They will have large doors that can be opened by the astronauts during orbital maintenance, that have access to some of the components of the spacecraft. This is another major structure about to be finished at Lockheed, the forward light shield [fig. 16]. It is the part that fits on top of the telescope. It has a 14-foot diameter, and simply provides the external cover for the metering truss and provides not only a light shield but also a temperature environment for the optical telescope assembly. It carries the aperture door that also acts as a sun shield to protect the telescope from sunlight. We want to be able to observe not only on the eclipse side of the orbit, but also on the sunlit side of the orbit. This is another equipment section which rests on top of the one you saw earlier, and it is built by Lockheed for Perkin-Elmer [fig. 17]. It has been shipped to Perkin-Elmer and they are now putting in their components, such as fine guidance sensor, and other electronics equipment that goes with the OTA. Originally, the plan was to make it all part of the OTA and then very early in the program we changed to this approach, which is a much more practical one.

I want to mention that Lockheed, of course, has a number of subcontractor items, such as tape recorders, batteries, reaction wheels, part of the control system, and these components have all been kept on schedule. The majority of them have been received and the remainder will be received shortly. We do not see any problem in that. The assembly and verification facilities was completed at Lockheed [fig. 18]. You see it under construction. This is what it looks like right now, the interior. We plan to move the instruments in early next year as the first occupants of this new facility.

This is a picture of the very large payload canister [fig. 19]. You can see the people standing there. This is really what the cargo bay of the shuttle looks like. So, we are just providing a replica and it is important that these doors lock very tightly. This system will provide the environmental control that we need to maintain for the telescope; no humidity and no salt during the long journey from Sunnyvale to the cape.

The pointing control system was a major technical concern a year or two ago and as I presented last year, we had just agreed that we would need to change the rate gyros and make a mechanical modification in the shroud in order to reduce the noise. The gyros are playing a very important part in the pointing control that we discussed earlier and these modified gyros are now being tested. These tests are being conducted at Holloman Air Force Base. Results are very good, very promising, coming in actually better than required. So, we have a good accomplishment there.

I want to show you a picture from Bristol, England [fig. 20]. Here are the solar arrays. This is one of two major wings which you can see on each side of the telescope. They are being assembled as shown in this picture. The cells themselves are being manufactured

in Germany and the electronics that follows the Sun every time the space telescope maneuvers is also being developed in Germany at Dornier Systems.

I will now address another element of the project—the scientific instruments [fig. 22]. As I mentioned earier, these are being managed by Goddard. We have five, shown on this sketch [fig. 21]. Two are cameras, one is being developed by JPL, one by the Europeans. We have a photometer that measures the brightness and location of the stars, and we have two spectrographs, one which is very sensitive to faint objects, the other one to resolution. This is a very good complement which was selected by a separate science committee. There's no infrared instrument, but we can exchange any one at any time for a new one with different scientific objectives. They are all at an advanced state of qualification test. Most of the qualification tests of these instruments are now nearing completion. The software that is required for the computer that interfaces with the spacecraft computer is well underway and we have planned and scheduled a major test series of first one and then combinations of these instruments at Goddard. We call it the verification and acceptance program, and this will start in May of this year. Following that, we will, of course, ship the instruments one at a time to Lockheed, where they go through receiving inspection and then start integration testing with the support systems module at Lockheed.

We have two problems at the present time. The high resolution spectrograph has two digicons that are still noisier than the principal investigator would like. This is a high voltage phenomenon. These instruments are using very high voltages. They are being tested in the chamber. They may not have had enough time to really outgas so that there is still some hope that we can avoid replacement of these digicons. But there is a spare available should one or the other of these digicons be too noisy. The other problem we had on the Eruopean camera was a faulty detector tube. These photon detectors were from Westinghouse in the United States and turned out to be a poor design and subject to mechanical failure during vibration tests. So we had to go to a redesign. Westinghouse produced new tubes that are a much better design. The tubes have been delivered, and assembly is underway, but we have lost some time. So we do not expect to deliver this camera before September, which is only 2 months before completion of the acceptance at Goddard, which is very tight. Of course, it is assumed that there will be no further failures during the testing that is now ongoing. But other than these two current problems, I would say that all instruments are in very good shape and supporting this important test date at Goddard.

Figure 23 shows schematically how the Mission Operations System will work, and figure 24 shows the present status of the mission and science operations. Again the telescope will receive commands from the ground concerning what to do next, and, in turn, transmitting science data to the tracking satellite, which in turn will transmit the data to the ground station of the NASA ground communication network, and then to the Operations Control Center at Goddard. At this point, we are looking primarily for engineering data and some limited science data; those that are re-

quired to see the functional performance of the instruments that might require some action to lower temperatures or whatever. Associated with this control center is a science support center that is connected with the Science Institute, and scientists are working hand in hand with the control center people to get an early warning on pending developments in the satellite.

They make the control center aware of the next observing sequence that is established at the Sceince Institute. There is some computer support that is obviously needed and that is the base that we are using at Goddard for this, as well as for other control centers. There is a special new facility being built for space telescope, and it will, in the future, be used on other programs as well, called the data capture facility, which will receive the mainstream science data, format it into convenient packages, and then transmit it twice a day to the Science Institute in a format that is compatible with that they are designing their computer systems to utilize. The Science Institute facility is shown here [fig. 25]. The exterior is almost complete. We are now working on the inside and hope to occupy it by the middle of this year. The Science Institute itself has a staff of people under Dr. Giacconi. They have already been working for more than a year now at Johns Hopkins. Management executive staffing is completed and has already assigned a number of people. We expect to bring that up to about 10 during 1983.

The science operations ground system is a contracted effort with TRW and it provides the software and the computer base required to do the processing of the science data in such a way that the scientists can actually use it. It is, of course, a system very close to the Science Institute. They are perfecting their requirements. We have had design reviews. We have completed the hardware definition and the software design being done by TRW is progressing very well. But, as you might expect, the Science Institute people have found a lot of things that they felt are needed, and we expect the requirements that were initially contracted with TRW to increase somewhat. It may go all the way up to 25 percent in order to make this a really viable system. Here again you could ask why didn't we see this before. The reason is that we didn't really have all the people who have to use the system on board when the contract was let.

My last chart [fig. 26] shows the planned activities for next year. Probably the most important activity is to complete the program replanning that is required in response to the delays that I described at Perkin-Elmer. It should be completed this coming month. The manufacturing of the support systems module at Lockheed should be completed next year. The primary mirror assembly should be entirely complete. We are now just about ready for the last optical test to prove that the mirror surface has not changed inspite of the assembly into the main ring. After that we will go ahead with the optical telescope assembly itself. We should have all instruments, including the European, delivered to Goddard. Goddard will conduct the verification acceptance program that I mentioned, with the first instrument and will receive the last instrument in September. The science institute should be completed and running in support of preparations for launch.

This, in short, is the presentation I have prepared.

Chairman VOLKMER. The telescope will be in low Earth orbit. Will it be along the Equator?

Dr. SPEER. It will be a low inclination of 28.5°, not exactly an equatorial orbit.

Chairman VOLKMER. So what effect will the Sun have on the heating problems?

Dr. SPEER. That is one of the major challenges that remains. We go from very high temperatures on the sunlit side to very low temperatures on the eclipse side and that's a problem for the solar arrays and the thermal control system and the pointing control system. We have very high performance insulation on every part that needs to be protected, all the structures that you saw and we have the temperature in the observatory at room temperature of 60° to 70°. Heaters will come on when the outside temperature goes down. We have analyzed and found that this will operate within a couple of degrees.

Chairman VOLKMER. Can you maintain temperature?

Dr. SPEER. Within a couple of degrees.

Dr. LUCAS. That's right.

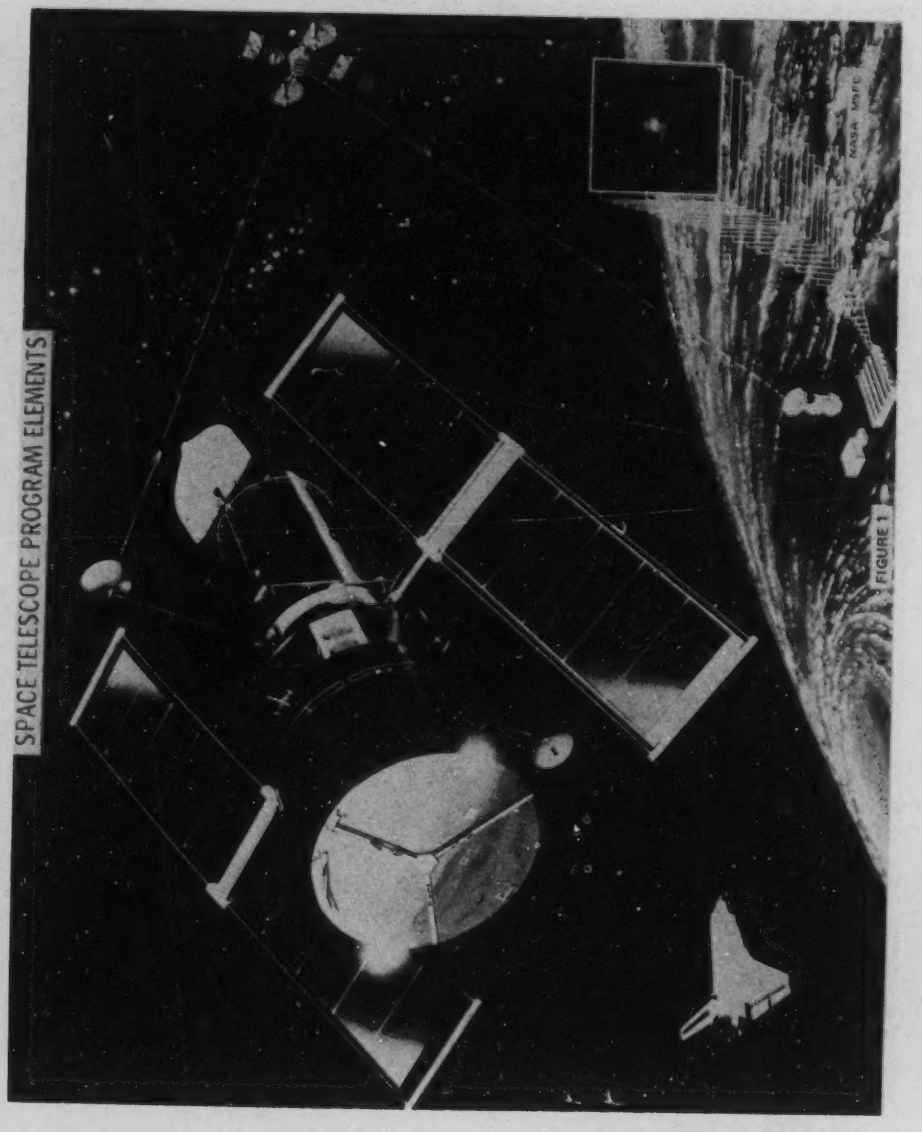
Chairman VOLKMER. The other thing is, will the telescope never point directly at the Sun?

Dr. SPEER. We have to stay out 50°. Any closer and the aperture door will automatically close. This would be a malfunction, not a planned event.

Chairman VOLKMER. Thank you, very much.

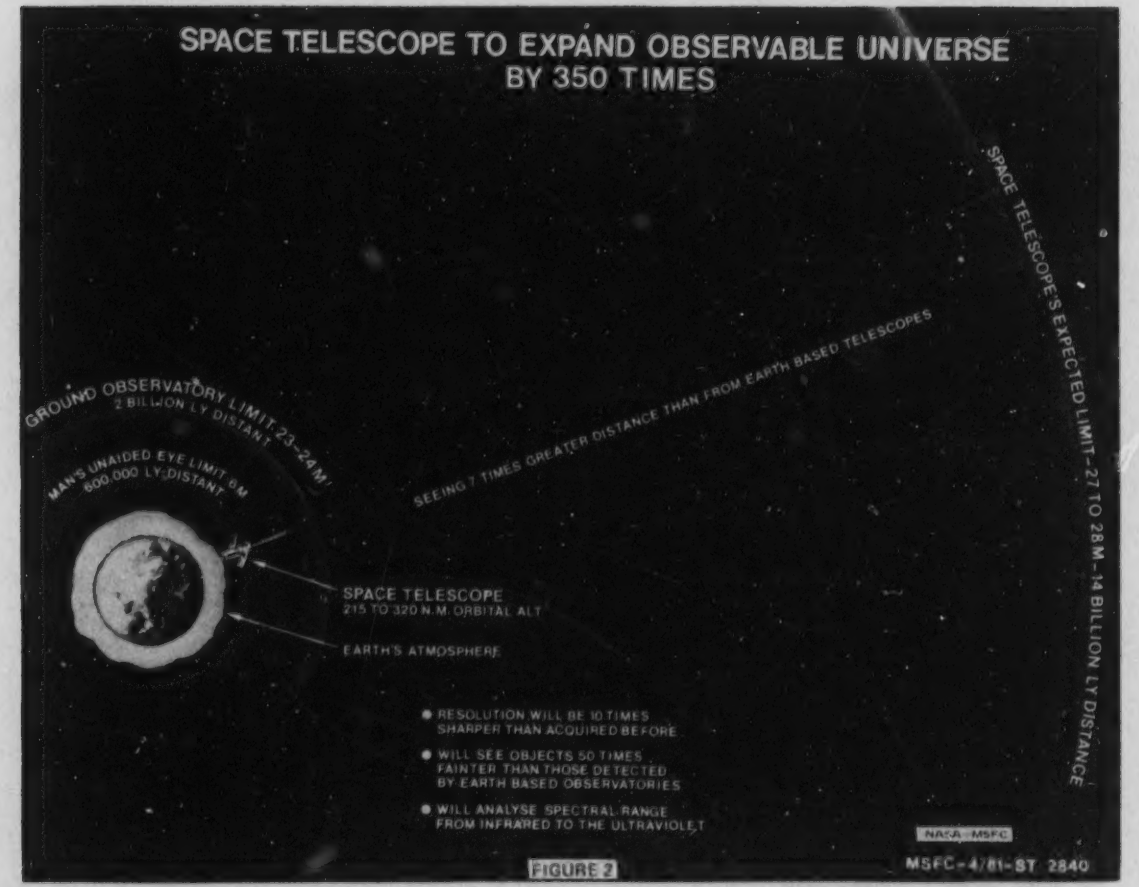
Dr. LUCAS. Mr. Chairman, the final planned presentation this morning will be by Bob Marshall, Director of Program Development, who will be describing some of our studies and future projects.

[Figs. 1-26 of Dr. Speer's oral presentation, plus his prepared statement, follow:]



SPACE TELESCOPE PROGRAM ELEMENTS

FIGURE 1


SPACE TELESCOPE TO EXPAND OBSERVABLE UNIVERSE BY 350 TIMES
SPACE TELESCOPE'S EXPECTED LIMIT–27 TO 28M–14 BILLION LY DISTANCE
SEEING 7 TIMES GREATER DISTANCE THAN FROM EARTH BASED TELESCOPES
GROUND OBSERVATORY LIMIT 23–24M
2 BILLION LY DISTANT
MAN'S UNAIDED EYE LIMIT 6M
600,000 LY DISTANT
SPACE TELESCOPE
215 TO 320 N.M. ORBITAL ALT
EARTH'S ATMOSPHERE
• RESOLUTION WILL BE 10 TIMES SHARPER THAN ACQUIRED BEFORE
• WILL SEE OBJECTS 50 TIMES FAINTER THAN THOSE DETECTED BY EARTH BASED OBSERVATORIES
• WILL ANALYSE SPECTRAL RANGE FROM INFRARED TO THE ULTRAVIOLET
NASA–MSFC
MSFC–4/81–ST 2840
FIGURE 2

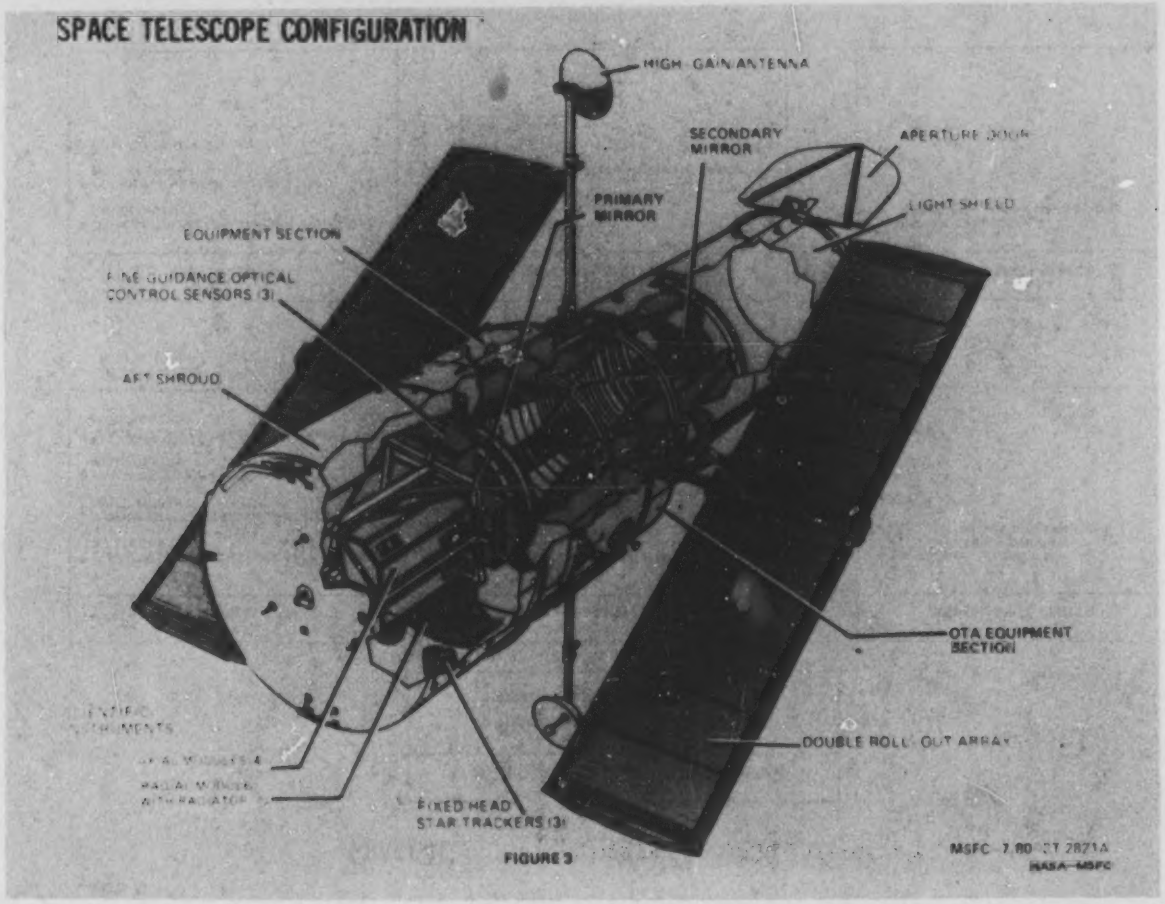

SPACE TELESCOPE CONFIGURATION
HIGH GAIN ANTENNA
SECONDARY MIRROR
APERTURE DOOR
PRIMARY MIRROR
LIGHT SHIELD
EQUIPMENT SECTION
FINE GUIDANCE OPTICAL CONTROL SENSORS (3)
AFT SHROUD
OTA EQUIPMENT SECTION
DOUBLE ROLL OUT ARRAY
FIXED HEAD STAR TRACKERS (3)
MSFC 7 80 ST 2871A
NASA-MSFC

FIGURE 3

4377–82

SPACE TELESCOPE PROJECT RESPONSIBILITIES

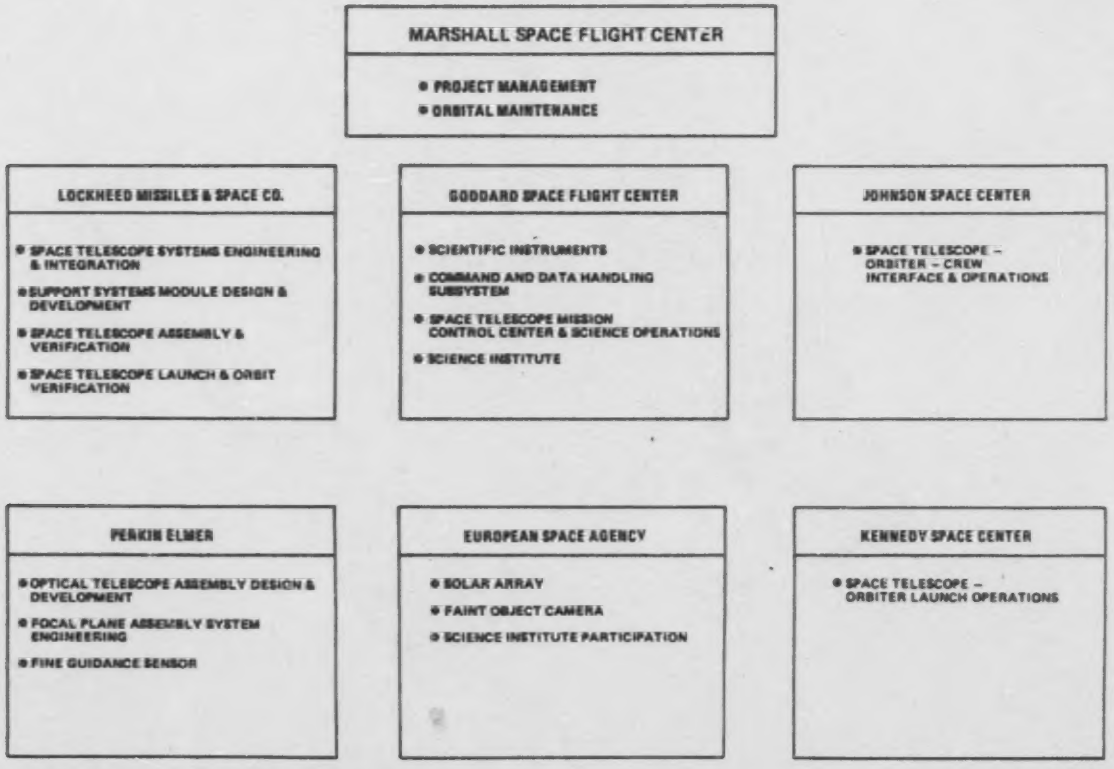

MARSHALL SPACE FLIGHT CENTER
• PROJECT MANAGEMENT
• ORBITAL MAINTENANCE
LOCKHEED MISSILES & SPACE CO.
• SPACE TELESCOPE SYSTEMS ENGINEERING & INTEGRATION
• SUPPORT SYSTEMS MODULE DESIGN & DEVELOPMENT
• SPACE TELESCOPE ASSEMBLY & VERIFICATION
• SPACE TELESCOPE LAUNCH & ORBIT VERIFICATION
GODDARD SPACE FLIGHT CENTER
• SCIENTIFIC INSTRUMENTS
• COMMAND AND DATA HANDLING SUBSYSTEM
• SPACE TELESCOPE MISSION CONTROL CENTER & SCIENCE OPERATIONS
• SCIENCE INSTITUTE
JOHNSON SPACE CENTER
• SPACE TELESCOPE – ORBITER – CREW INTERFACE & OPERATIONS
PERKIN ELMER
• OPTICAL TELESCOPE ASSEMBLY DESIGN & DEVELOPMENT
• FOCAL PLANE ASSEMBLY SYSTEM ENGINEERING
• FINE GUIDANCE SENSOR
EUROPEAN SPACE AGENCY
• SOLAR ARRAY
• FAINT OBJECT CAMERA
• SCIENCE INSTITUTE PARTICIPATION
KENNEDY SPACE CENTER
• SPACE TELESCOPE – ORBITER LAUNCH OPERATIONS

FIGURE 4

NASA–MSFC

SPACE TELESCOPE PROJECT

STATUS

- OPTICAL TELESCOPE ASSEMBLY
  - PRIMARY AND SECONDARY FLIGHT MIRRORS - POLISHED AND COATED
  - MAJOR STRUCTURAL ELEMENTS - FABRICATION COMPLETED
  - MAJOR QUALIFICATION TESTS - STARTED
  - PRIMARY MIRROR ASSEMBLY - INTEGRATION BEHIND SCHEDULE
  - FIRST FLIGHT UNIT FINE GUIDANCE SENSOR - ASSEMBLY BEHIND SCHEDULE
  - MAJOR GROUND HANDLING EQUIPMENT - DOLLY AND TOOLING RING - COMPLETED INTEGRATION COMPLETED
  - SPECIAL TEST EQUIPMENT - REQUIREMENTS IDENTIFIED
  - AIR TRANSPORTATION - MODE AND EQUIPMENT BASELINED
  - SCIENTIFIC INSTRUMENT LATCHES - QUALIFICATION TEST PROGRAM UNDERWAY

1073

FIGURE 5

NASA—MSFC

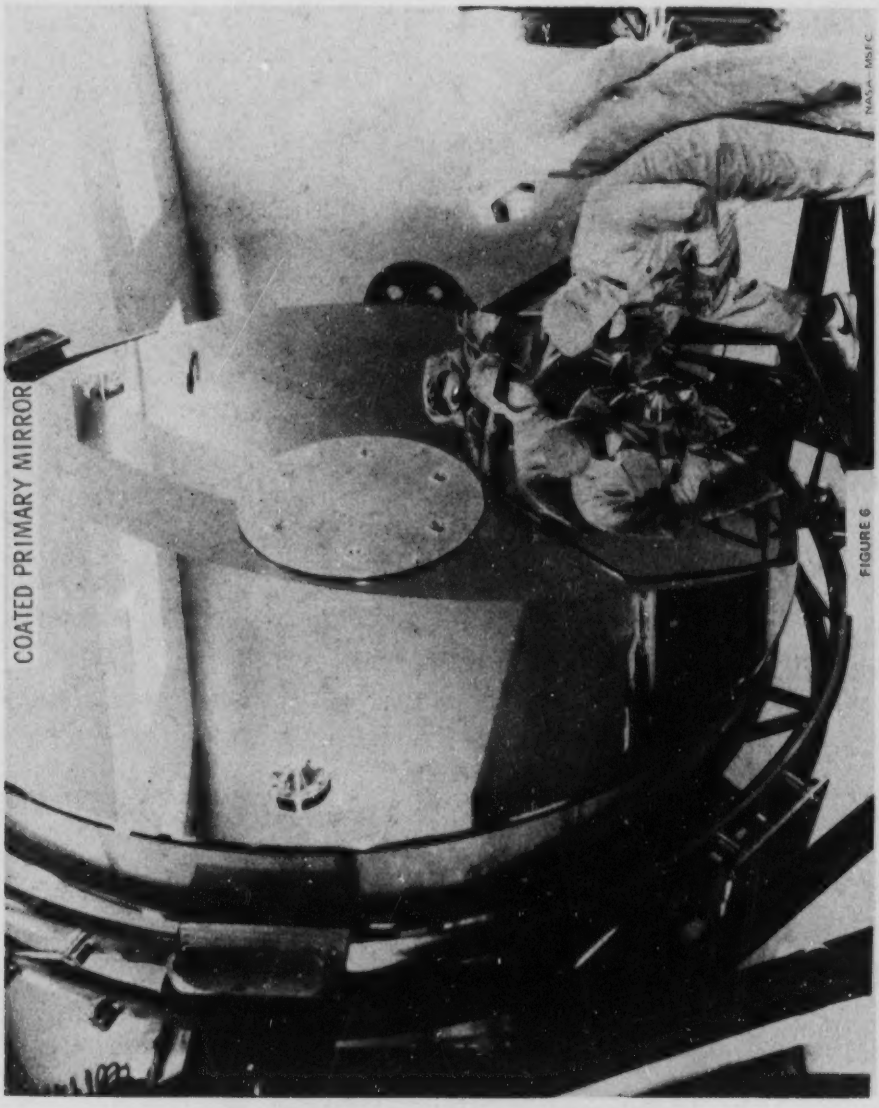
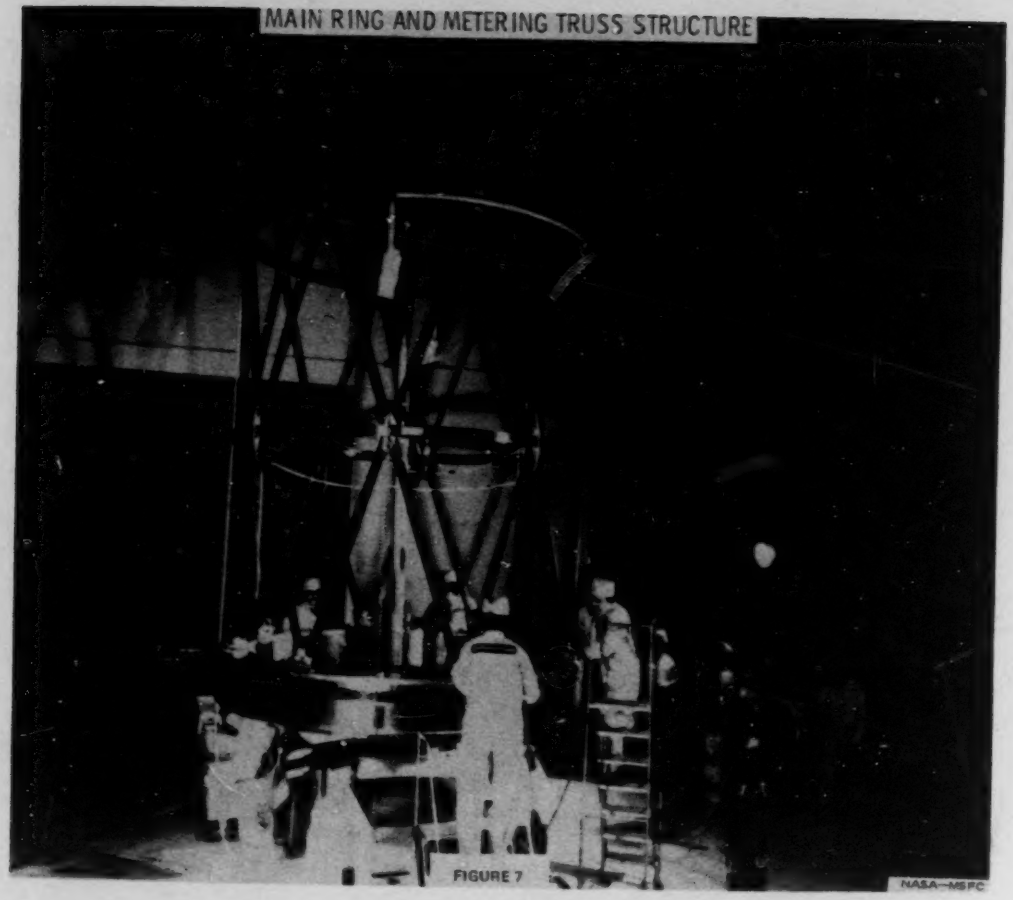


FIGURE 6


MAIN RING AND METERING TRUSS STRUCTURE
FIGURE 7
NASA—MSFC

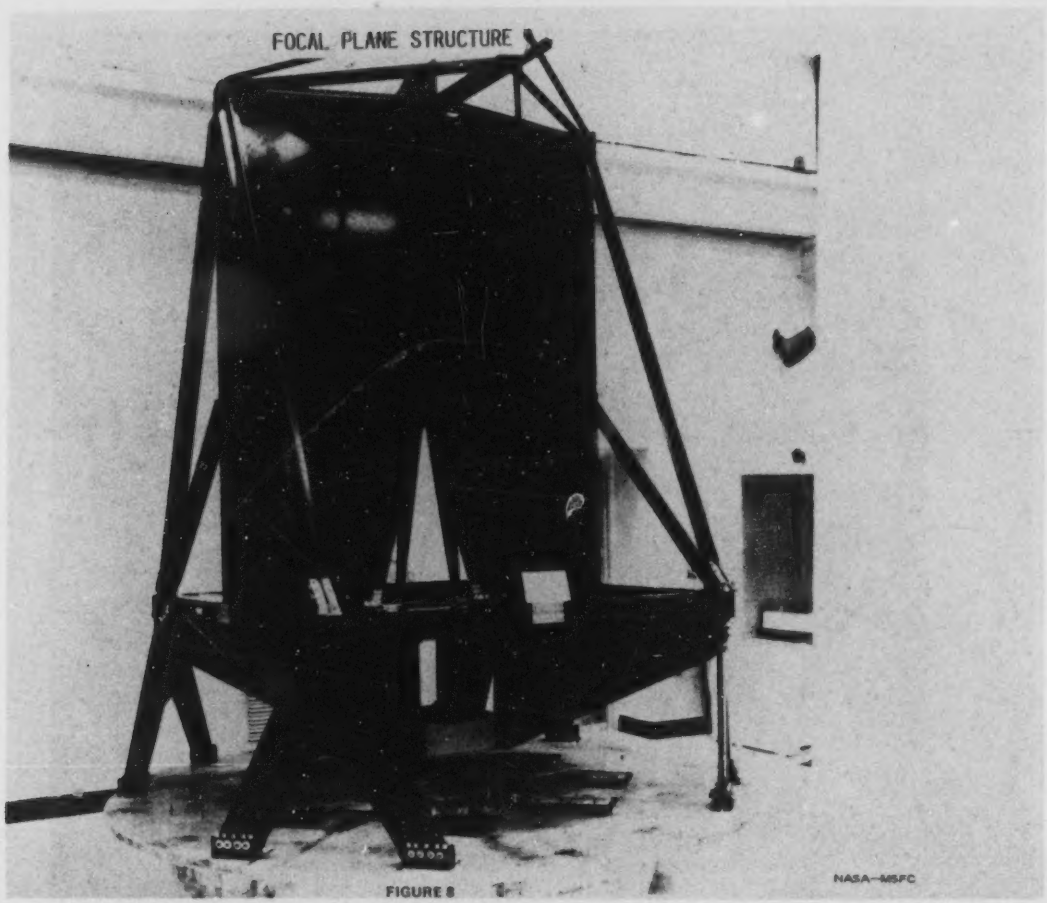


FIGURE 8

FIGURE 9

PRIMARY MIRROR - MAIN RING
INTEGRATION

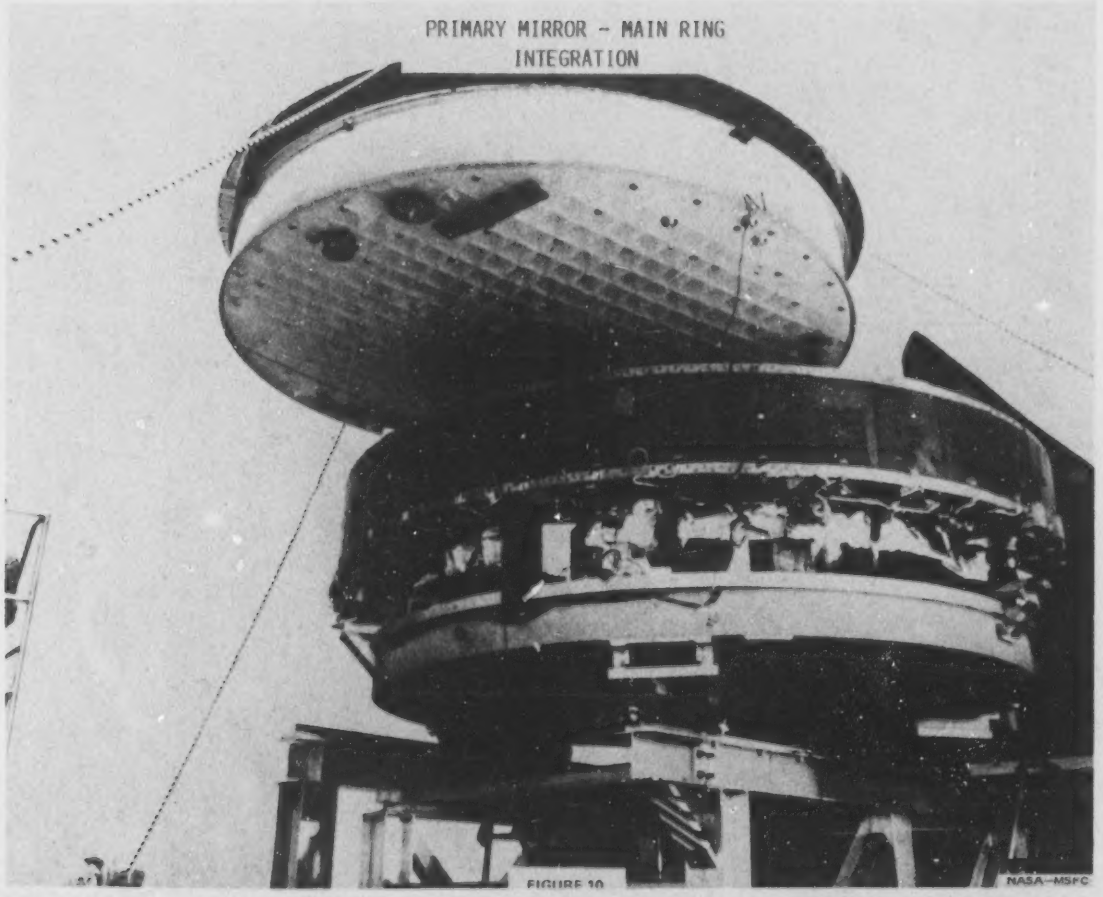


FIGURE 10

NASA-MSFC

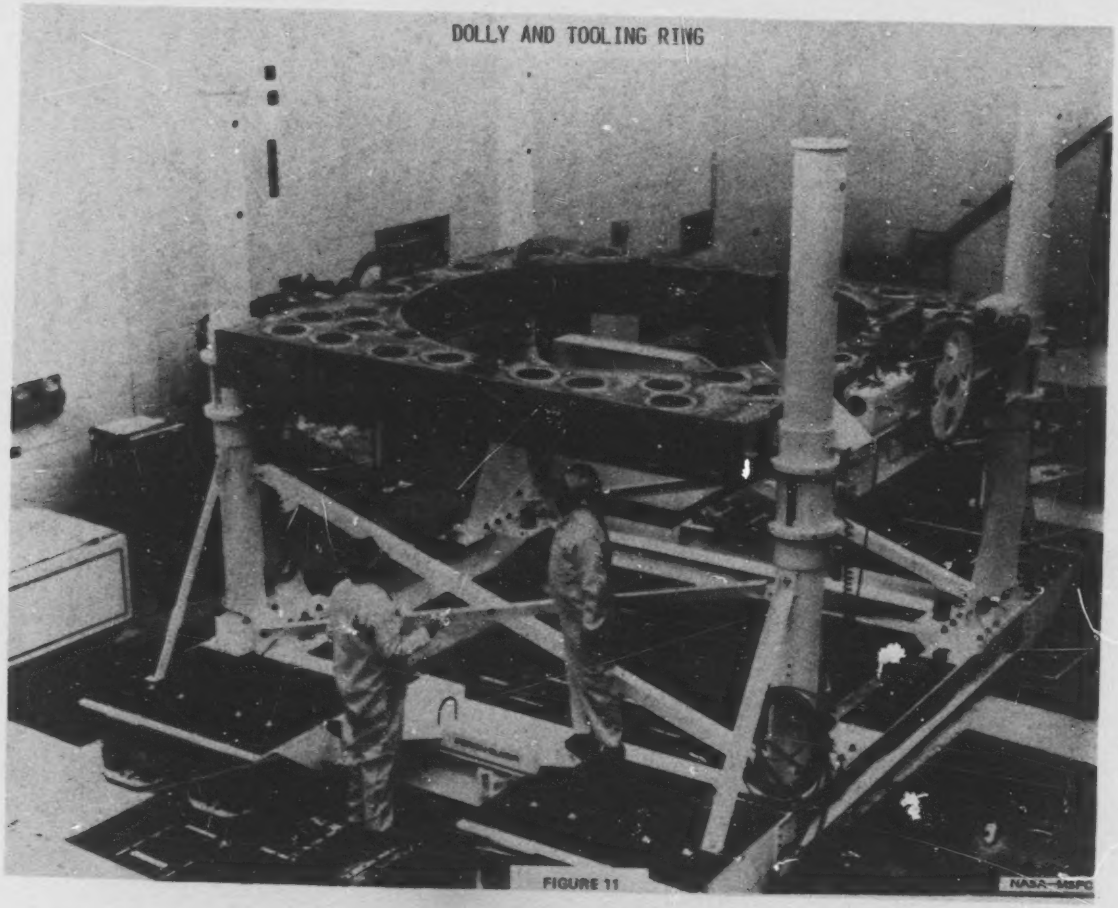


FIGURE 11

NASA
L-71-4704

ATM TRANSPORT CONTAINER

FIGURE 12

NASA-MSFC

SPACE TELESCOPE PROJECT
PROGRAM REPLANNING

- SCHEDULE DELAYS IN OPTICAL TELESCOPE ASSEMBLY FABRICATION
  - PRIMARY MIRROR ASSEMBLY INTEGRATION DELAYED - SEP 82 TO FEB 83
  - COMPLETION OF FINE GUIDANCE SENSOR #1 ASSEMBLY DELAYED - OCT 83 TO JAN 84
  - FOCAL PLANE STRUCTURE MODIFICATION
  - SUBSTANTIAL, ADDITIONAL SPECIAL TEST EQUIPMENT REQUIRED
- CORRECTIVE ACTIONS BEING TAKEN BY NASA AND PERKIN-ELMER
  - NASA/MSFC
    - HAS MOVED MSFC PROJECT OFFICE TO CONTRACTOR SITE
    - REBALANCING PROGRAM RESOURCES
  - PERKIN-ELMER
    - HAS MADE SIGNIFICANT MANAGEMENT AND ORGANIZATIONAL CHANGES
      - NEW PROGRAM MANAGER AND CORPORATE MANAGEMENT INVOLVED IN DAY-TO-DAY OPERATIONS
      - HAS INCREASED MANPOWER DEVOTED TO OPTICAL TELESCOPE ASSEMBLY
      - ESTABLISHING ACHIEVABLE SCHEDULES - RECOGNIZING ADDITIONAL SKILLS REQUIRED
- PROGRAM SCHEDULE AND COST TO BE REBASELINED BY MARCH 1983
  - OPTICAL TELESCOPE ASSEMBLY DELIVERY TO LMSC WILL BE DELAYED
  - OVERALL PROGRAM IMPACT TO BE MINIMIZED

FIGURE 13

NASA—MSFC

SPACE TELESCOPE PROJECT

STATUS
(CONT'D)

- SUPPORT SYSTEMS MODULE
  - CRITICAL DESIGN REVIEWS - COMPLETED
  - MAJOR STRUCTURAL ELEMENTS - FABRICATION COMPLETED
  - MAJOR STRUCTURAL ITEMS FOR ASSOCIATE CONTRACTORS - DELIVERED
  - SUBCONTRACTOR SUBSYSTEMS AND COMPONENTS - MAJORITY RECEIVED
  - ASSEMBLY AND VERIFICATION FACILITIES - CONSTRUCTION COMPLETED
  - POINTING CONTROL SYSTEM PERFORMANCE - REQUIREMENTS BEING MET
  - WATER TRANSPORTATION - MODE AND EQUIPMENT BASELINED
- SOLAR ARRAYS
  - DEVELOPMENT MODEL WINGS - ASSEMBLY AND TESTING COMPLETED
  - FLIGHT UNIT SOLAR ARRAY BLANKETS - FABRICATION AND TEST COMPLETED
  - DEPLOYMENT ELECTRONICS - DESIGN COMPLETED

1082

FIGURE 14

NASA–MSFC

SSM EQUIPMENT SECTION
PRIMARY STRUCTURAL ASSEMBLY

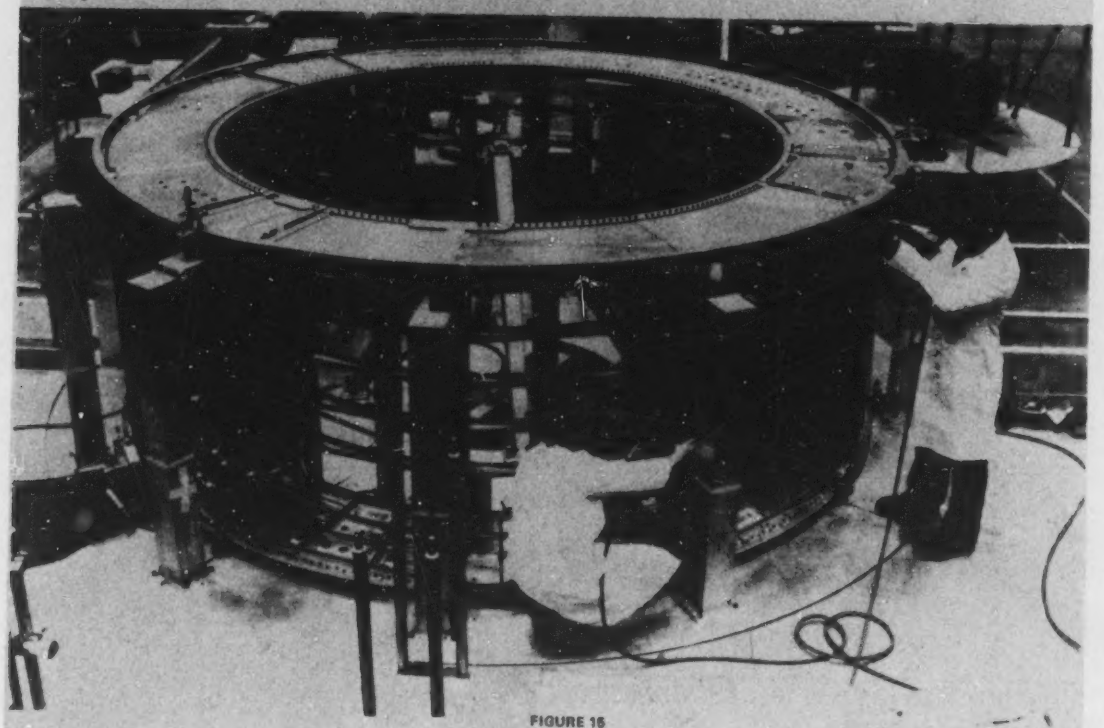


FIGURE 16

NASA–MSFC

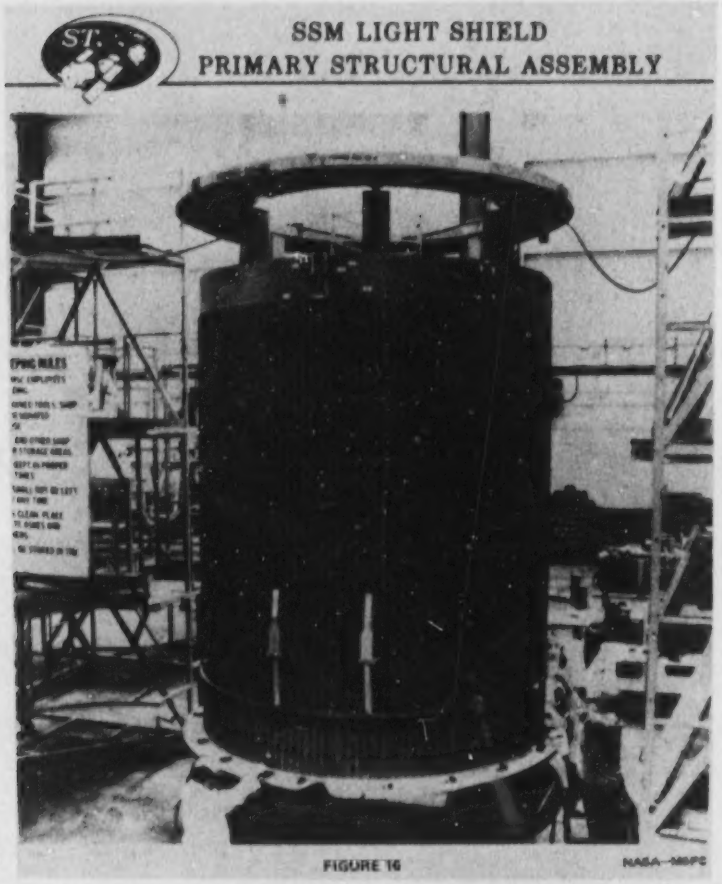


FIGURE 16

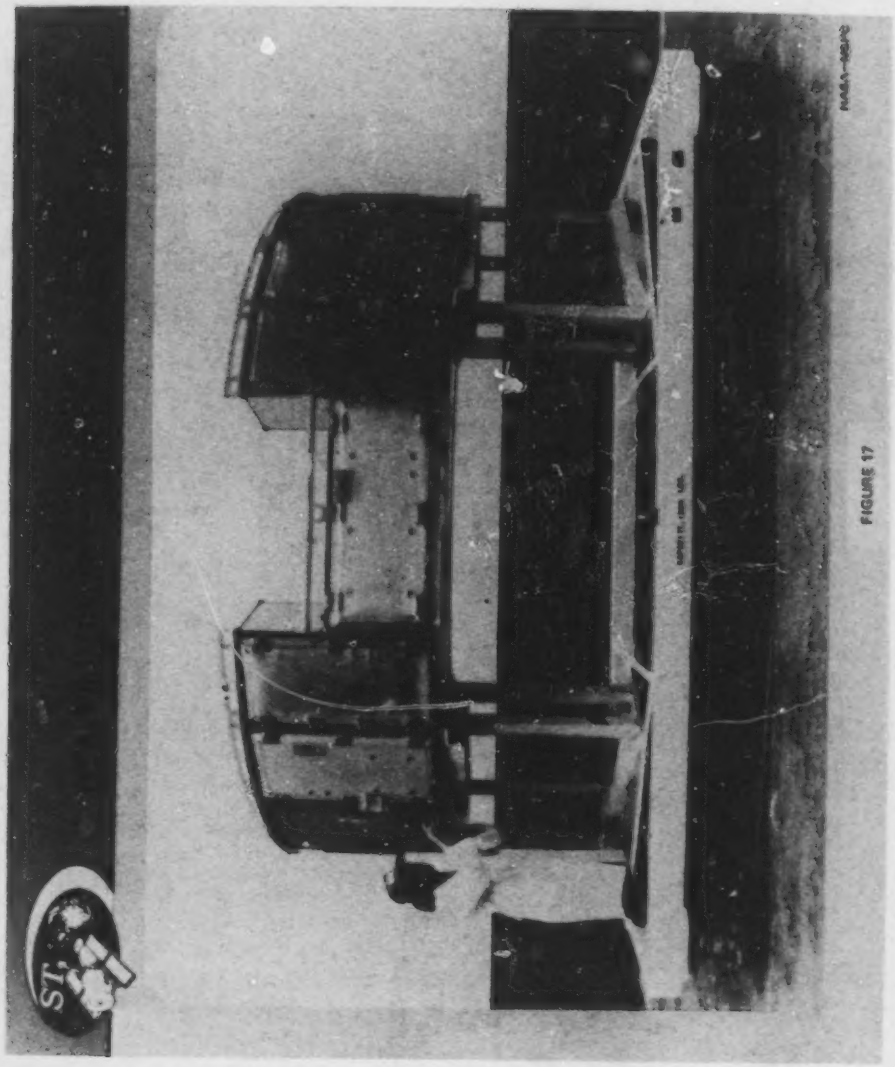


FIGURE 17

FIGURE 18

KSC PAYLOAD CANISTER
NASA
FIGURE 19

FIGURE 20

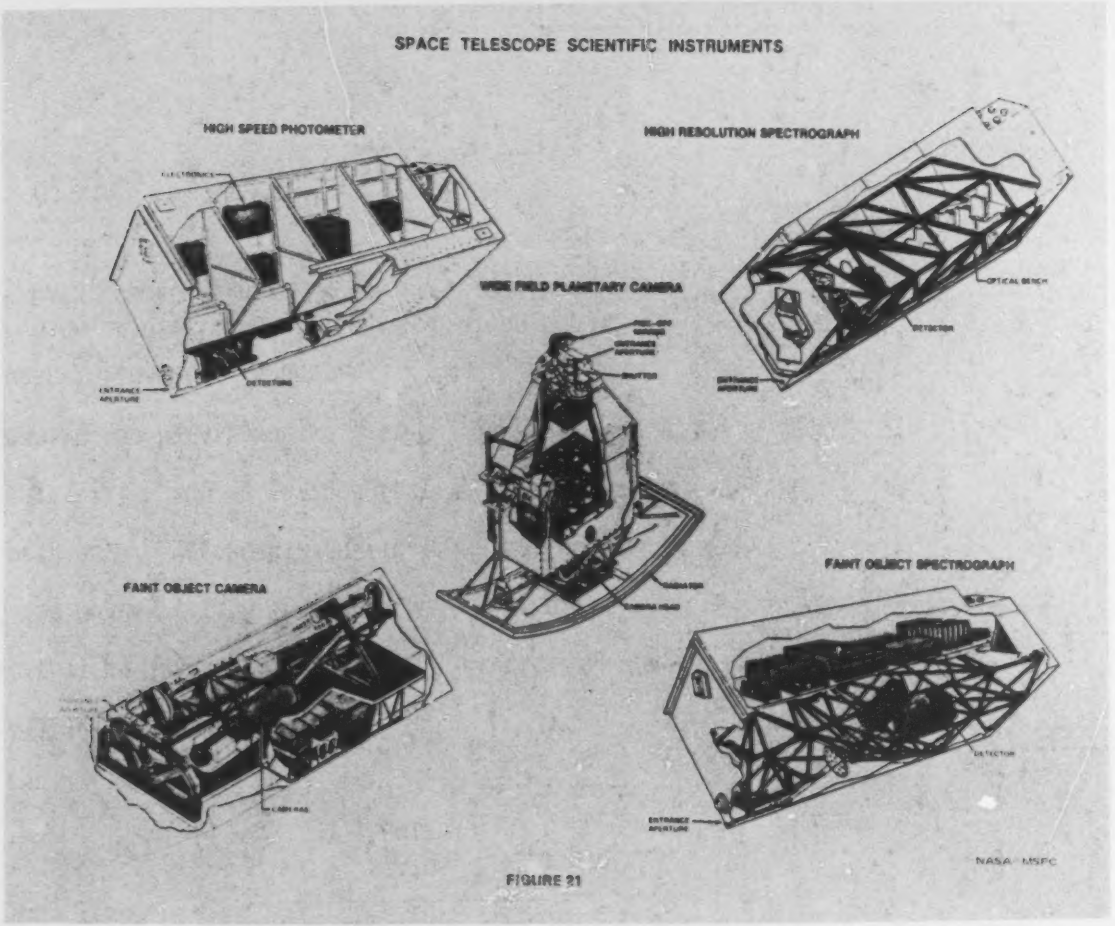

SPACE TELESCOPE SCIENTIFIC INSTRUMENTS
HIGH SPEED PHOTOMETER
HIGH RESOLUTION SPECTROGRAPH
WIDE FIELD PLANETARY CAMERA
FAINT OBJECT CAMERA
FAINT OBJECT SPECTROGRAPH
NASA - MSFC

FIGURE 21

SPACE TELESCOPE PROJECT

STATUS
(CONT'D)

- SCIENTIFIC INSTRUMENTS

  - SCIENTIFIC INSTRUMENTS HARDWARE - FABRICATION COMPLETED
  - MAJOR QUALIFICATION TESTING - NEAR COMPLETION
  - SOFTWARE - DEVELOPMENT/VERIFICATION TESTING WELL UNDERWAY
  - VERIFICATION AND ACCEPTANCE TESTING - STARTS MAY 83 AT GSFC
  - COMMAND AND DATA HANDLING SYSTEM - IN FINAL ASSEMBLY AND TEST
  - CURRENT TECHNICAL ISSUES
    - HIGH RESOLUTION SPECTROGRAPH DIGICONS
    - FAINT OBJECT CAMERA PHOTON DETECTOR TUBES

1090

FIGURE 22

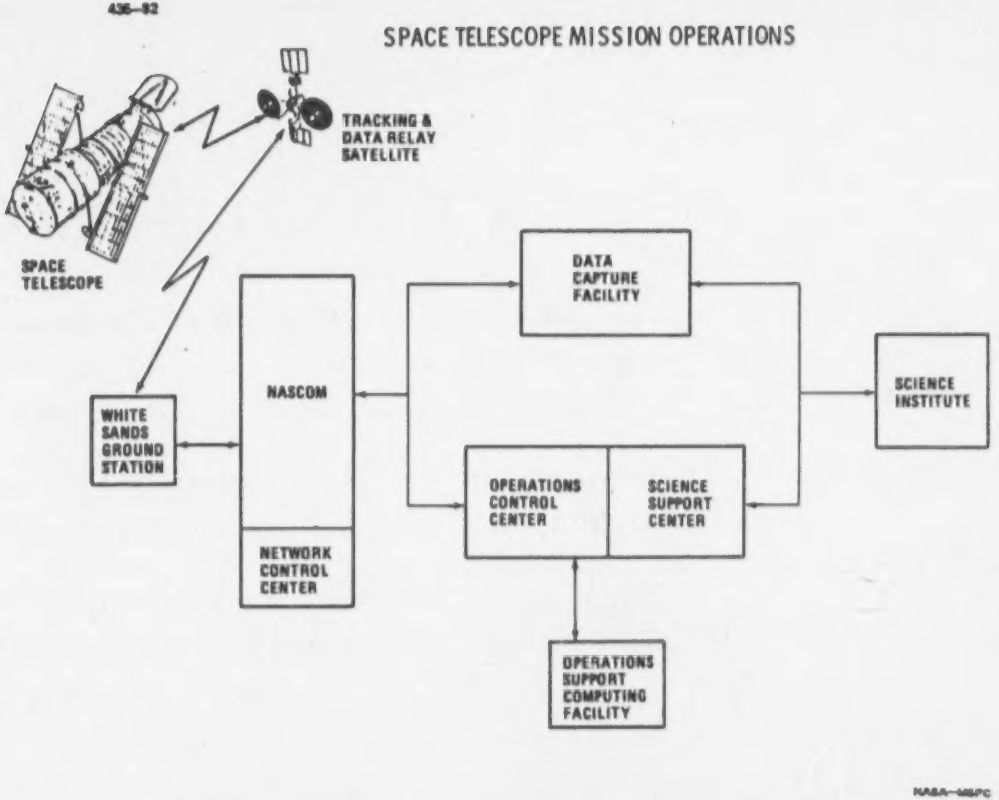

SPACE TELESCOPE MISSION OPERATIONS
TRACKING & DATA RELAY SATELLITE
SPACE TELESCOPE
DATA CAPTURE FACILITY
SCIENCE INSTITUTE
WHITE SANDS GROUND STATION
NASCOM
NETWORK CONTROL CENTER
OPERATIONS CONTROL CENTER
SCIENCE SUPPORT CENTER
OPERATIONS SUPPORT COMPUTING FACILITY

FIGURE 23

SPACE TELESCOPE PROJECT

STATUS
(CONT'D)

- MISSION AND SCIENCE OPERATIONS
  - SCIENCE INSTITUTE FACILITY CONSTRUCTION - NEARING COMPLETION
    - BENEFICIAL OCCUPANCY - BY MID-1983
  - SCIENCE INSTITUTE SENIOR MANAGEMENT AND TECHNICAL STAFFING - COMPLETED
    - ESA HAS STARTED FILLING ITS ASSIGNED POSITIONS IN INSTITUTE
  - SCIENCE OPERATIONS GROUND SYSTEM DESIGN - WELL UNDERWAY
    - CRITICAL DESIGN REVIEW - PLANNED FOR MID-MARCH 1983
    - HARDWARE DEFINITION COMPLETED - ITEMS ON ORDER
    - SOFTWARE DESIGN - PROGRESSING VERY WELL
    - REQUIREMENTS HAVE INCREASED

1092

FIGURE 24

STATEMENT

of

DR. FRED A. SPEER
MANAGER, SPACE TELESCOPE PROJECT

Mr. Chairman and Members of the Subcommittee:

This statement presents the status of the Space Telescope Project through February 1983. It includes descriptions of major project accomplishments and major activities planned for the coming year. Figure 1 shows the Space Telescope configuration with its major elements. A specific description of the configuration is not included since it is essentially the same as described in previous testimony to the Subcommittee.

The Space Telescope is being developed as a general purpose astronomical observatory in space with an anticipated lifetime of more than a decade. After launch to orbit by the Space Shuttle, the Space Telescope will be the first long term, national astronomical observatory in space. In fact, the Space Telescope will be an international astronomical observatory, as participation by scientists from other countries is now in the planning stage. The availability of the Space Shuttle will allow the Shuttle crew to perform selected in-orbit repair of the observatory and the exchange of scientific instruments, and, if necessary, return the entire observatory to earth for refurbishment and subsequent re-launch to orbit.

The Space Telescope will represent a tremendous step forward from the largest existing groundbased telescopes, and its existence will represent a gain similar to that of Galileo's first astronomical telescope. It is anticipated that many of its discoveries will be just as significant, for it will reveal the largest portion of the universe, which is now only barely perceived. In fact, the scientist will be able to see seven times farther into space than with groundbased telescopes, with a resolution ten times better, and observe objects which are fifty times fainter.

While in orbit, the observatory operations will be conducted by two major ground operations system elements, i.e., the Space Telescope Science Institute and the Space Telescope Operations Control Center. The Science Institute has been established to implement the National Aeronautics and Space Administration Space Telescope science policy, to solicit, evaluate, and select observational proposals submitted by competing observers, to coordinate correlative research, and to coordinate international participation. During the in-orbit operations, the Science Institute will generate candidate observing schedules and instructions, and reduce and analyze scientific data. The Operations Control Center is being established to perform mission scheduling, to monitor the status of the observatory, to process and analyze engineering data, and in the event of Space Telescope systems problems, to initiate corrective action.

During this period, a number of fabrication problems and schedule delays were identified which will affect the original commitment for Space Telescope cost and schedule. These problems and delays are discussed later in the appropriate sections of this statement.

MAJOR ACCOMPLISHMENTS

Major accomplishments since February 1982 include: Critical Design Reviews for the Space Telescope overall system and the Support Systems Module; fabrication of hardware for the Optical Telescope Assembly, Support Systems Module, Solar Arrays, and the Scientific Instruments; major development testing; Space Telescope integration; selection of major transportation modes and equipment for the Optical Telescope Assembly and the assembled Space Telescope; design reviews for major elements of the operations ground system; construction of facilities for the Science Institute; in-orbit maintenance development tests in the Marshall Space Flight Center (MSFC), Neutral Buoyancy Simulator; and development of the maintenance and refurbishment activities.

Critical Design Reviews (CDRs) - The CDRs scheduled for the Space Telescope overall system and the Support Systems Module were completed as planned in March 1982. The Project assessment of these reviews has been completed and, no significant difficulties with the designs were found. The Support Systems Module was declared ready for the manufacturing phase.

Hardware Fabrication - Substantial progress was made during the year of 1982 in flight hardware fabrication for various major elements of the Optical Telescope Assembly. Integration of the Primary Mirror Assembly, which consists of the large 96-inch Primary Mirror, the Main Ring, the Reaction Plate and the Primary Mirror Figure Control

Actuators, was started in August 1982. Figure 2 shows the Primary Mirror being placed into the Main Ring during integration at Perkin-Elmer in Danbury, CT. The Focal Plane Structure, Figure 3, was modified to provide higher, positive margins of safety for the mounting feet of the four large structural interface flexures. The modification was completed in November 1982, and involved the installation of titanium "Boots" over the existing mounting feet, as shown in Figure 4. The assembly of the first flight unit Fine Guidance Sensor was started in July 1982. Fabrication and integration of major ground support handling equipment was also completed during 1982; for example, Optical Telescope Assembly dolly in April 1982, tooling ring in August 1982 and integration of these two items in December 1982, as shown in Figure 5.

Substantial progress was also made in the fabrication of a number of major subsystems and components for the Support Systems Module by the Lockheed Missiles and Space Company (LMSC), Sunnyvale, CA. Major structural elements completed for the Support Systems Module includes: assembly of the primary structure for the Equipment Section, as shown in Figure 6, which houses the majority of the electronics and battery systems; the light shield, as shown in Figure 7, which encases a portion of the forward end of the Optical Telescope Assembly; and the structural assembly tooling for the forward shell and the aft shroud. The manufacturing drawings for the flight Data Management Unit were completed and fabrication of a pre-production unit and a flight unit was initiated. Major items completed and delivered to the associate contractors include: the Optical Telescope Assembly equipment section as shown in Figure 8, the Rate Gyro Assembly and Fixed Head Star Tracker thermal and structural simulators and interfacing electrical parts to Perkin-Elmer, and the Scientific Instruments, Command and Data Handling Subsystem Orbital Replacement Unit structural tray to Fairchild. A significant number of subcontractor flight hardware deliveries were made during this period. A complete flight complement of Magnetic Torquers, Fixed Head Star Trackers, Radio-frequency Circulation Switch, Magnetometers and High Gain Antenna Dish and Feed Assemblies were delivered to LMSC, along with the spare flight computer. Significant progress was also made in the flight hardware build-up of the low-noise shrouded rate gyro assemblies, and the retrofit of the flight Reaction Wheel Assemblies with bearings that yield low induced vibrations.

Good progress was made during 1982 in the fabrication of major subsystems and components of the European Space Agency (ESA) provided Solar Arrays. The assembly and testing of the development model solar array wings was completed, and the flight unit solar cell blankets were also completed.

Substantial progress was also made during 1982 in the fabrication of the Scientific Instruments and the Command and Data Handling Subsystem. A typical Scientific Instrument, the High Speed Photometer, is shown as Figure 9. The Faint Object Spectrograph, being developed by the University of California at San Diego and the Martin Company, Denver, CO, is nearing completion of the assembly and optics alignment phase, and the electrical performance characterization testing will be initiated in the near future. The Faint Object Camera, being developed by ESA, preliminary system level testing has been completed. The delivery of this instrument to GSFC for the Verification/Acceptance Program will be later than planned due to schedule delays caused by re-work of the Photon Detector Assembly flight camera tubes, which has been completed, and potting problems with the tubes being experienced in Europe. GSFC is assisting ESA in the resolution of this problem. The High Speed Photometer, being developed by the University of Wisconsin, Madison, WI, is now assembled and testing is almost complete. This instrument passed the thermal/vacuum qualification test with only very minor, correctible difficulties. The High Resolution Spectrograph, being developed by GSFC and Ball Aerospace Division, Boulder, CO, has been assembled, the optics have been aligned, and electrical performance has been verified. Environmental testing has been initiated. Investigations of noise in flight and spare digicon detectors are currently being conducted. The cause of the noise problem is still unknown, as well as, the potential impact on scientific objectives. The Wide Field/Planetary Camera, being developed by the Jet Propulsion Laboratory, Pasadena, CA, has experienced accelerated progress during the last year. Assembly operations are almost completed and electrical systems testing has been initiated. Substantial progress has also been made in software development for all Scientific Instruments and, in every case, the instruments are operating, partially or completely, with their ground test computers and software. The Command and Data Handling Subsystem, being developed by the Fairchild Space Company, Germantown, MD, is also nearing completion, and is presently undergoing final electrical, assembly and environmental testing.

Major Development Testing - The axial Scientific Instrument (SI) latches are being subjected to flight level dynamic, qualification testing at MSFC. The latches were tested in October and December 1982, and experienced a failure of the aluminum oxide ceramic latch coating plus excessive galling of the mating titanium latch half. As a result of these test failures, a tungsten carbide/cobalt coating has been applied to the galling susceptible materials, and retesting of these newly coated parts will begin on or before April 1983.

Space Telescope Integration - The Space Transportation System/Space Telescope Phase II Safety Review was completed during this period. This review focused on potential hazards to the Space Shuttle which might be precipitated by Space Telescope during the launch phase and deployment of the Space Telescope on-orbit. The review concluded that all potential hazards are controlled.

Pointing Control System (PCS) analyses continued at a high level during 1982 and the results indicate that the very demanding 0.007 arc second line of sight jitter performance requirement is achievable. The incorporation of the shroud modification to the Rate Gyro Assembly to reduce noise and the reduction of Reaction Wheel induced vibration through a bearing retrofit activity significantly improved the line of sight jitter performance as well as the margin on loss of lock performance due to Rate Gyro noise.

Assembly and verification activities during this period included baselining the Space Telescope Assembly and Verification Plan and the Space Telescope Verification Requirements document. Construction activities were completed on the Assembly and Verification facility at LMSC, as shown in Figure 10, and the installation of mechanical ground support equipment into this facility has started.

Transportation Modes and Equipment - The transportation modes and equipment for the Optical Telescope Assembly move from Danbury, CT to the integration site at LMSC, Sunnyvale, CA, and the move of the integrated Space Telescope to the launch site at KSC, were selected during 1982. The Optical Telescope Assembly will use the Apollo Telescope Mount container, as shown in Figure 11, which will be modified for this specific application, and will be moved via air transportation. The integrated Space Telescope will be enclosed in the KSC Payload Canister, as shown in Figure 12, and moved via water transportation on a ship provided by the Military Sealift Command, or a barge provided by NASA. The KSC Payload Canister will require only minor modifications for this application.

Operations Ground System - The Preliminary Requirements Review and Preliminary Design Review for the Science Operations Ground System were conducted during 1982. The hardware definition has been completed, and the majority of the items have been placed on order. The software design is well advanced, and coding at the systems level has been initiated. However, requirements have increased significantly as the result of requirements and design reviews, and now represent a cost risk to the program.

Science Institute - The Science Institute facility con-

struction at Johns Hopkins University, Baltimore, MD, is nearing completion, Figure 13, and beneficial occupancy is planned for mid-year 1983. The Guide Star Selection System Preliminary and Critical Design Reviews have been completed, and no major design deficiencies have been identified. Staffing of senior management and technical positions has been completed, and ESA has begun filling its assigned positions at the Institute.

In-Orbit Maintenance Development Tests - In-orbit maintenance development tests were conducted in the MSFC Neutral Buoyancy Simulator, Figure 14, during 1982 to verify concepts for the maintenance mission space support equipment in support of the preliminary design activities.

Maintenance and Refurbishment - The Maintenance Mission Development Plan and the Space Telescope Life Cycle Plan were revised in June 1982 to be consistent with the maturing Space Telescope design. Maintenance and refurbishment implementation planning was completed, including the identification of task requirements supporting schedule and procurement approach. A preliminary Logistics Plan was completed to initiate development of the logistics management program. Effort was initiated to establish the maintenance and refurbishment data base by computerizing the available Space Telescope hardware inventory and initiating development of hardware operating procedures. An interim design review or the maintenance mission space support equipment was conducted in July 1982, to assure compatibility with the various project elements. In support of this activity, the Space Telescope/Space Support Equipment Interface Control Document has been initiated. The selection of the maintenance and refurbishment contractor has been delayed, at least until FY-1984, and specific support requirements are being incorporated into the existing Space Telescope contracts.

PROGRAM REPLANNING

During this period, schedule delays were identified by the Optical Telescope Assembly contractor, Perkin-Elmer, which have resulted in a significant increase in manpower above that planned for and increased cost projections for FY-1983 and beyond. The Primary Mirror Assembly, for example, will be completed later than had been forecast, the Fine Guidance Sensor assembly will require more time than planned, and a significant amount of Special Test Equipment was identified beyond that previously known. As a result of these problems, NASA and Perkin-Elmer management have initiated a number of corrective measures which have just been implemented. Perkin-Elmer has increased the manpower level, including needed skills, and made significant changes in management and program organization, including a new Program

Manager and direct involvement of Corporate Management in the day-to-day operations. NASA has moved the Optical Telescope Assembly Project Manager and his immediate staff to the contractor's site to improve communications and response time. Perkin-Elmer is refining schedule and cost projections to establish the earliest feasible date for delivery of the Optical Telescope Assembly to LMSC for integration into the Space Telescope. NASA is assessing the overall Space Telescope Program schedule and resources to identify adjustments or rebaselining of resources that will be required for the program rebaselining. This assessment should be completed and a new baseline schedule established by the end of March 1983.

PLANNED MAJOR ACTIVITIES

The next 12 months will be devoted to: continued hardware fabrication, assembly, integration and testing; major qualification testing; development of the major elements of the operations ground system; completion of Science Institute facility construction; in-orbit maintenance development tests in the Marshall Space Flight Center (MSFC) Neutral Buoyancy Simulator; development of the maintenance and refurbishment effort; and rescheduling the Optical Telescope Assembly detailed functions.

Hardware Fabrication - The fabrication efforts for the Optical Telescope Assembly will concentrate on: Primary Mirror Assembly integration and testing; Optical Telescope Assembly, assembly and verification; Special Test Equipment design and hardware fabrication; assembly of the Fine Guidance Sensor; and assembly and verification of the Fine Guidance Electronics.

The Support Systems Module hardware fabrication efforts will concentrate on: completion of all flight hardware and ground support equipment required for the initiation of the Equipment Section checkout late this year; completion of Data Management System hardware/software validation test; delivery of all remaining subcontractor hardware; and completion of most mechanisms for deploying and latching the Solar Array, High Gain Antennas and Aperture Door.

The Scientific Instruments hardware fabrication efforts will concentrate on those items needed to complete the instruments, perform the environmental testing and deliver them to GSFC for the Verification and Acceptance Program, where each instrument will be electrically tested in conjunction with the Command and Data Handling subsystem and the flight software which resides within the onboard computer. Subsequently, multiple instruments will be electrically tested to assess mutual compatibility for concurrent in-orbit operations. These activities are

planned for completion by the end of 1983, after which the instruments and related equipment will be delivered to LMSC for future integration into the Space Telescope.

Major Qualification Testing - The axial and radial Scientific Instrument and the Fine Guidance Sensor latches will be qualified by strength and dynamic testing scheduled for March through October 1983. When the titanium carbide/cobalt coated latches have successfully completed their dynamic qualification test, all latch halves susceptible to galling will be retrofitted and substituted for the flight latches presently installed on the Scientific Instruments, with final alignment recertification being performed at GSFC following the retrofit.

Operations Ground System - The Science Operations Ground System development will be nearing completion at the end of 1983, and preparations for system interaction and test will be underway in early 1984.

Science Institute - The development of operations procedures will begin in 1983, and the core of the Science Data Analysis Software will be nearing completion at year's end. The Institute facility will be completed and occupied by mid-1983. Also, during 1983 the Guide Star Selection System software will be developed and the entire system will be undergoing integration and test with completion planned for February 1984.

In-Orbit Maintenance Development Tests - In-orbit maintenance development tests will be conducted during 1983, to verify the Space Support Equipment design.

Maintenance and Refurbishment - The Maintenance and Refurbishment Procurement Plan will be revised during 1983 to reflect contractor selection in FY-1984. The Preliminary Design Review for the Space Support Equipment for the maintenance mission will be conducted in July 1983.

Rescheduling of Optical Telescope Assembly Effort - A major effort is underway to reschedule the Optical Telescope Assembly effort, including very detailed Level IV schedules, and this effort will be completed in the first quarter of 1983.

SUMMARY

In summary, the Space Telescope Project is making substantial progress in all areas in satisfying program requirements. Assembly, integration, and test operations are well underway, and all technical and scientific requirements are being met. Technical and management problems at Perkin-Elmer have caused substantial schedule delays in the start of assembling the Optical Telescope Assembly, and will affect the commitment for Space Telescope schedule and cost. Therefore, close attention is being given to meeting schedule milestones and quality of work with special emphasis on minimizing the effect of the Perkin-Elmer delays on the other program elements and the total program cost.

TRANSCRIPT OF TESTIMONY

by

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DIRECTOR, PROGRAM DEVELOPMENT
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MR. MARSHALL: Mr. Chairman, Mr. Luján, Mr. Flippo, I will be discussing the Advanced Programs as Dr. Lucas indicated at the beginning of the presentation. The left column on Figure 1 shows the approved programs that have already been discussed with you in some detail. I will be discussing those programs that are assigned for definition and those that are proposed for the future. I will not discuss the Tethered Satellite System at this time. It is shaped like a very small ball of about one meter in diameter. It will be suspended from the Shuttle into the atmosphere. It is in the new start program for 1984. Additionally, the Gravity Probe B, Dr. Lucas mentioned Gravity Probe A, is an experiment which would test Einstein's General Theory of Relativity concerning gravitational affects on space. We are completing our Phase B activity on this program. I will discuss in detail the other programs listed.

I will first discuss our Space Station/Space Platform activity. Our approach for a program of this size is to

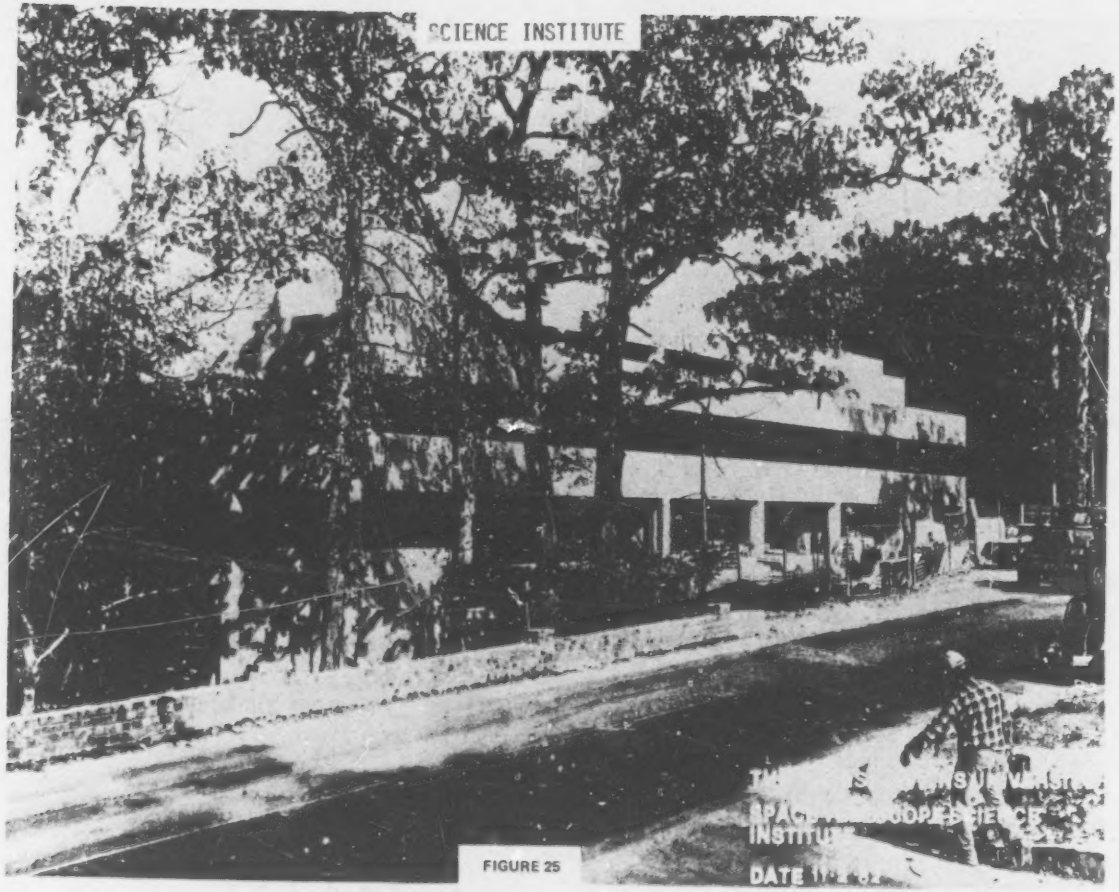


FIGURE 25

SPACE TELESCOPE PROJECT

PLANNED MAJOR ACTIVITIES - 1983

- Complete Space Telescope Program Replanning
- Complete Manufacturing of Support Systems Module Major Structural Elements
- Complete Primary Mirror Assembly Integration and Start Optical Telescope Assembly
- Deliver Scientific Instruments to GSFC and Conduct the Verification/ Acceptance Program
- Complete Science Institute Facility Construction and Move Institute Personnel into the Building

FIGURE 26

start with where we are today (indicating Figure 3), which is the Space Shuttle, the Spacelab, the Centaur and IUS vehicles, and focus on a long range plan or goal in order to drive technology. Technology takes about ten to fifteen years depending on the severity of the advancement in the state-of-the-art. The manned geosynchronous operations would be a long term goal on which we would focus the technology uses. A nearer term major goal that has been identified with the Administration is a long-duration manned space facility or Space Station. We would probably start with a manable facility which would be smaller than the ultimate long range facility. I will explain in a few minutes what I mean by this step during my discussion of evolution.

Along with the need for a manable facility, there is a potential need for an unmanned geostationary facility like the communications satellites we have today. We have a geostationary concept where we have replaced a number of our smaller satellites with a single larger satellite. The arc over the United States where communications satellites are located has begun to get crowded. There are only ten slots available so there is need for a consolidation approach to keep communications expanding.

Manned sortie missions are something we will be doing eventually and there are some study plans now as how that might be accomplished.

The Space Station will probably evolve and be deployed by 1990 (Figure 4). From now through 1990 there will be orbital operational technology development. For example, there is the Orbit Transfer Vehicle space-basing concept. We must learn how to space-base an Orbit Transfer Vehicle, in order to achieve the higher capabilities of delivery to geostationary orbit (the orbit at which we can look up and a satellite is always overhead). There are studies that suggest that space-basing would be an economical way of doing the transfer from low-earth orbit to synchronous orbit. As to the space-basing concept, we don't yet know how to do propellant transfer and a number of other functions that would be associated with basing. We are presently addressing some experiments that will be done on a Space Station over a longer period of time and ultimately become an operational system.

We speak of large space structures assembly and there are a number of activities that require large space structures. If we have a large geostationary platform with antenna designed for communications, some of those antenna may be erected in low-earth orbit and transferred to synchronous orbit. There is the potential to capture the sun's energy and then convert that to electricity and beaming it back to the Earth. These collectors would be large structures. We are doing preliminary experiments to learn (1) the dynamics of how these structures perform, and (2) how man can interact with them in a zero gravity environment. We

will continue these efforts with experiments on the Shuttle today and will expand the activity by using the Space Station when its available. Spacecraft servicing is a concept that is growing quickly. The Space Telescope, which Dr. Speer briefed you on earlier, will be a spacecraft serviceable structure. It will be in a 28½° orbit and can be brought to a Space Station to accomplish that spacecraft servicing. There are other spacecraft that are in orbit today which can be serviced. The Solar Maximum Mission is the first of those spacecraft service missions. How we do spacecraft servicing is not yet clear except for what the astronauts can do. We want to move in a direction of automated spacecraft servicing. The satellites in synchronous orbit cannot be serviced by man and will be serviced via automation. We are addressing techniques and the technology necessary to accomplish spacecraft servicing and that too will be demonstrated by using a low-earth orbiting Space Station.

The commercial utilization, of course, is very important. Dr. Lucas mentioned materials processing in his briefing. I will show you some additional work that we are doing to identify commercial users. We are presently in contact with a number of private sector companies that have the potential of moving into the commercial applications in space. We will do early experiments in the Shuttle and then move into a Space Station laboratory where instead of two or

three hours of investigation you can do two or three days, weeks, months or years continuous research. Longer research time is necessary to realize commercial utilization of the materials processing in space. The national security potential uses for Space Station are being studied under a different set of studies. All these activities will define the growth Space Station configuration.

REPRESENTATIVE LUJAN: Let me ask you a question about that. My general idea is the Space Station will have to be in low-earth orbit. You couldn't have a Space Station in geosynchronous orbit, could you?

MR. MARSHALL: Yes you could have one in geosynchronous orbit.

REPRESENTATIVE LUJAN: Could you man it up there?

MR. MARSHALL: Yes sir, we could. In fact, we have completed studies and concepts and are calling it an "outpost". The Space Station would not be large, e.g., it would provide a place to stay where you would keep your supplies, etc., to accomplish your mission. This habitat would be home while service missions were accomplished and then the man would return to LEO. It is within the realm of possibility to accomplish manned synchronous missions.

REPRESENTATIVE LUJAN: Your earlier remarks about a station were the place to stop at low orbit and then launch and return there.

MR. MARSHALL: Yes, that is correct. I will show a chart later that pictorially shows that concept.

Also, along with the Space Station activities, we are progressing in space transportation. As you know, the Centaur vehicle has been selected to give us a larger capability into the geosynchronous orbit. The future delivery will be moving toward reuseable orbital transfer vehicles (OTV's) which provide an economical advantage to throw away vehicles. Reuse, like the Shuttle, requires space-basing. Additionally, there are future payloads under consideration that would exceed the payload capability of the Shuttle system. We have studies underway to develop vehicles that could accommodate larger payloads utilizing the Shuttle technology. Finally, there would need to be a manned module capability developed that would allow us to have access to geosynchronous orbit and there are studies to define that capability. During this time, science and applications missions are being studied from the standpoint of utilizing a Space Station.

REPRESENTATIVE LUJAN: Centaur - is that the same rocket, the Centaur rocket that was used before?

MR. MARSHALL: This is the Centaur which was used before.

REPRESENTATIVE FLIPPO: No sir, it is not the same one.

CHAIRMAN VOLKMER: Built on the same knowledge. Same type I should say.

MR. MARSHALL: Same type and sometimes referred to as the "fat tank" in that the tanks have been increased in size.

REPRESENTATIVE FLIPPO: That is the one NASA is developing for the Air Force.

MR. MARSHALL: As shown on Figure 5, we have completed our Phase B definition efforts on the Space Platform and we are prepared to start the hardware design. We had initially thought that this would be the first step in the permanent manned presence in space and we would add to that capability the systems necessary for manning. A study of that approach has been completed showing a method of getting to permanent manned presence in space. Presently we are addressing a Space Station which is a growth Space Station and we are in the process of doing technology studies and trades in-house.

Figure 6 shows a version of an unmanned Space Platform. It is composed of pallets which would fly in the Shuttle during the timeframe prior to its being available to function as an independent platform for science and commercial payloads. The platform provides utilities in space comparable to lights, power and gas on the ground, and allows payloads to be left in orbit for 90 days, 180 days and

longer. The Space Platform permits the Shuttle to function as a transportation system and payloads can be operated beyond the seven-day Shuttle limit. That was the purpose of having the Space Platform and its design is useable as the initial step toward a Space Station.

This particular picture, Figure 7, was used at the World's Fair in Knoxville. This brown area is a hangar for servicing OTV's. The hangar permits closing of the doors for work on the OTV in a confined area. This module on the end is similar to an erector set which is used to assemble parts, like a large mirror as shown in the picture. These astronauts give you some concept of the size structure being assembled. The small propulsion system shown is the Teleoperator Maneuvering System. The TMS is a vehicle for moving spacecraft to the Space Station for service. I'll speak of the TMS in more detail later. The Space Platform is shown in a separate orbit and is accommodating some commercial payloads.

CHAIRMAN VOLKMER: That's where you can do this materials processing.

MR. MARSHALL: That's correct, we would use the Teleoperator Maneuvering System as a harbor tug to move processed materials between the station and the factory. The station is shown in a 28½° orbit, which Dr. Speer mentioned during the Space Telescope discussion; which is to better orbit

for Shuttle delivery capability and spacecraft deployment. Also, it is an option orbit for launching geostationary platforms. There is a need to have the orbit over the poles, called polar orbit, which is best for earth viewing. Thus, we could have unmanned platforms located at polar orbit, and the manned station at the 28½° orbit with unmanned platforms available to do the science and commercial processing. This picture of two orbits and manned and unmanned operations represents a Space Station program.

REPRESENTATIVE LUJAN: Do you think we will start off in Space Station unmanned? What's your thoughts that we will start off that way with an unmanned one and then eventually add modules to it and make it manned?

MR. MARSHALL: We could start that way. Our present study thrust is to start with a manned system of less capability than desired and evolve to more capability as needed. We have considered starting unmanned and have completed those studies. Unmanned first is a very promising approach.

REPRESENTATIVE LUJAN: But you basically think that we will start with manned?

MR. MARSHALL: The current thrust is to start with a manned system.

REPRESENTATIVE FLIPPO: Is that technology pretty well just putting together a group of Spacelabs?

MR. MARSHALL: Yes, it is. You can start with Spacelab technology and replace the Spacelab with higher technology capability later. It depends on what your pocketbook says you can do at the time.

I want to discuss briefly some of the activities that we are doing here on the Space Station (Figure 8). I think you are familiar with the Mission Analysis Studies. These contracts are being completed now. Additionally, we have at the Marshall Center three additional studies that address the technology I mentioned on the earlier chart which were the structures, the satellite servicing and OTV servicing. The purpose of these studies is to do two things: If you say I'm going to service the satellite, that says the satellite has got to be configured to be serviced, so we need to define the requirements for the satellite. Also, the Space Station has to be able to service spacecraft, the Space Station must be configured to do it. So these three studies are attempting to answer those two questions looking in either direction and addressing the respective design requirements. The in-house Marshall activity, what we are doing at the Marshall Space Flight Center, can be broken into two specific areas. We're doing systems engineering and definition studies on mission requirements and architectural concepts. This chart (Figure 9) identifies our activities for the Headquarters Space Task Force. We are putting together what is called "yellow books". These are referenced back to the Shuttle development. We are currently

doing that for Space Station. The MSFC book is book number five which is systems definition. Book five is a key book in terms of influencing the decision on what the architecture and the configuration ultimately will be. Other Centers of NASA are also participating in this book. MSFC is leading the activity for the Agency and coordinating with the other Centers. Johnson Space Center is doing the systems requirements and characteristics book and helping Kennedy Space Center with the operations book. There is a total involvement of all Centers.

Figure 10 shows an example, answering an earlier question of how you might grow a Space Station. You might grow by replacement. By that I mean start with a very simple system, perhaps Spacelab technology. Then, once you have decided what is ultimately required, build the long range growth station. Some of the systems basically would be "started over again". Another concept would be to grow through evolution. Start with a single concept then add to its capability in time and bring the final capability to the ultimate need capability. Another approach is growth by replication. Start with a small unit and then grow with additional units as required. This approach has an advantage of location in various orbits of interest. Some stations could be isolated from the centered manned station because of hazardous operating conditions. This is an example of system studies we are doing to be sure that the first step is the right step for future growth. The equipment shown in

Figure 11 represents some of the advanced development Space Station test beds that we are doing at the Center. For the Space Station, a key area of design is the power system. The power system can be operated in a number of ways. There is direct current and there is alternating current. One has to decide which system to design. Once that choice is made, there is the question of the voltage level. These kinds of hardware questions and hardware activities are presently being addressed in our power laboratory. Figure 11 is a picture of a high voltage battery section test that is being done in the power lab. Additionally, we have the Space Station requirement of docking and berthing. Docking must be very carefully accomplished because the structures we are docking with have long deployed power array wings and any disturbance will cause them to "flop". Therefore, we need to understand precisely how we dock so that we don't put disturbances in to these structures. We have a docking simulation capability in the laboratory which consists of a piece of equipment that we had built for the lunar landing system. We are now using that equipment to dock with model spacecraft to define feedback systems to minimize structural disturbance. Precise attitude pointing and stabilization in the orbit is a requirement. We did the Skylab attitude control work here at the Center. The Skylab was the first Space Station and much of the equipment is being utilized today for the Space Station program studies. The attitude motion simulator shown here in Figure 13 was utilized for

Skylab. This facility is available and we are presently doing simulation studies with control moment gyros to develop the control laws of stabilization for the Space Station. And finally, Figure 14, is the Neutral Buoyancy Simulator facility. It is a large tank, 40 feet deep and 75 feet in diameter. We are trying to understand requirements and operations for on-orbit servicing. The picture shows one design concept on how to replace an entire Space Station. It's important for us to understand that we can replace a complete wing and design for that capability early in the program. We have produced a design and we are accomplishing the change in Neutral Buoyancy Simulation.

REPRESENTATIVE LUJAN: Do you have that designed into the Telescope capabilities?

MR. MARSHALL: There are some replaceable units in the Telescope - not all of the capabilities. I don't recall specifically how many line replaceable units are in the Telescope design.

MR. KINGSBURY: The solar array is replaceable, like the operation shown in the Neutral Buoyancy Simulator.

REPRESENTATIVE FLIPPO: Bob, there were some remarks about using the External Tank for some Space Station designs.

MR. MARSHALL: Yes, we have studied that in-house. In fact, Jim Kingsbury can be credited with inventing that concept

and it would be like the Skylab development. We believe that is an approach that has some advantages. There's a small study contract with San Diego University addressing that concept as an approach to Space Station.

REPRESENTATIVE LUJAN: One big station won't be able to use all those External Tanks.

MR. MARSHALL: There is a way of linking them together, and making an attractive system with some unique capabilities.

Figure 16 shows the Transfer Orbit Stage. This is a small stage for GEO transfer. It has commercial interest to two companies, Orbital Systems Corporation, who has a development agreement with Martin Marietta, and the Boeing Company. They have proposed to build the Transfer Orbit Stage (TOS) and then sell it commercially. So we, the NASA, presently are not in the process of funding these studies. These contractors have made a commitment to NASA and the arrangements are being negotiated at Headquarters. The interest in the Transfer Orbit Stage is the matching of Ariane IV payload capability. The TOS gives the United States a competitive system to Ariane IV. It is believed that TOS can be designed to be less costly than the IUS. It is possible to build TOS from the first stage of the IUS with some avionics that are presently available from other vehicles and make an attractive economical upper stage. This would give the kind of low cost delivery capability to the communication satel-

lite that they desire. Of course, the Wide Body Centaur we mentioned earlier has two capabilities in the short version and in the long version which exceed any known commercial capability available.

REPRESENTATIVE LUJAN: Do you mean in weights tossed up or how high up do you go?

MR. MARSHALL: Geosynchronous is the arc that most American business is interested in and these payload weights were referenced to that orbit.

REPRESENTATIVE LUJAN: Would TOS be launched off the Shuttle?

MR. MARSHALL: Yes, the Shuttle would deliver the TOS to low earth orbit for launch to synchronous orbit.

The Teleoperator Maneuvering System functions can be compared to an earth harbor tug. It looks like the concept shown in Figure 18. The TMS gives the Shuttle another dimension of capability that we believe is required. For example, as in Figure 19, it allows you to take payloads from the Shuttle, 160 nautical miles to higher orbits, deposit or retrieve payloads. You can do it much more efficiently because you're not raising a 150,000-pound Shuttle up to these orbits. This figure (19) shows a map of the TMS capability. For example, you can take a 20,000-pound payload, raise it up to 960 nautical miles and move it through 6° and leave and return the TMS to the Shuttle. You can

make a modest amount of orbital plane changes. The Teleoperator Maneuvering System gives you an expansion of the capability of the Shuttle. Additionally, the TMS can be left on orbit with the Spacecraft to maintain altitude or change position, as required. As I mentioned earlier, the TMS can maintain the Space Station altitude and serve as a "harbor tug" in the vicinity of the Space Station.

REPRESENTATIVE LUJAN: What stage is that in? Or are you just thinking about it?

MR. MARSHALL: We have completed the feasibility studies and are ready for Phase B. We would like to complete the Phase B and start the hardware program in the 1985 budget. Figure 20 shows an example of what it can do. The Advanced X-Ray Astrophysics Facility (AXAF) is about the size of the Space Telescope and is a program I will discuss later. This similar map can be applied to the Space Telescope. As an example, the Shuttle could deliver the telescope to 320 nautical miles, and in three years, because of the drag, it would decay to where you would have to revisit with the Shuttle. We would plan to update it at this visit. However, the Shuttle could only boost it back up to 260 nautical miles and then it will decay sooner and require another Shuttle visit. The Teleoperator Maneuvering System could deliver the spacecraft back to 320 nautical miles and return to the Shuttle. Thus, you eliminate three revisits by the Shuttle and save a substantial cost. As the schedule

on Figure 21 indicates, we are prepared for Phase B in the 1984 and a 1985 program start.

The Orbit Transfer Vehicle, Figure 23, is a new concept which we are developing which will require an advance in technology. The picture shows the transfer vehicle and a spacecraft returning from geosynchronous orbit. Its engine is fired at a modest thrust to generate a shock wave in front of the inflated ballute to reduce the heating as the spacecraft is coming back into the atmosphere. This is a promising approach for a reuseable Orbit Transfer Vehicle which utilizes aerodynamic braking into the atmosphere rather than using propulsive braking. Figure 24 shows lift to drag ratios of different vehicle configurations to do the return job. Using the earth's atmosphere saves energy for return in comparison to propulsive braking. The return vehicle would make a couple of orbits and then rendezvousing with the Orbiter for return to earth or be based at a Space Station. This map (Figure 25) indicates how aeroassist allows an OTV to deliver and return substantially more payloads than the all purpose propulsion vehicle. The reason is the braking energy is used up in the atmosphere with the aerodynamic drag. We are leading an effort with other NASA Centers and the Department of Defense in developing the technology.

CHAIRMAN VOLKMER: What would be the timeframe for reentry?

MR. MARSHALL: In terms of hours, it would be two to three orbits. Maybe as much as five to six hours.

CHAIRMAN VOLKMER: And that's all?

MR. MARSHALL: That's all.

CHAIRMAN VOLKMER: That's the one we just spoke of?

MR. MARSHALL: That's right. It's very quick. The energy is converted to heat and the material to accept the heat is the technology driver.

The Shuttle Derived Launch Vehicle as shown here on Figure 27, is a larger lift capability. We have taken the Shuttle technology and the Shuttle design and addressed how we might construct some additional unmanned vehicles with greater lift capability. An all-solid approach has been studied and would allow upwards of 100,000 pounds in low-earth orbit. These are the same solids used with the Shuttle. One concept uses solids and a shorter External Tank. Yet a third uses solids, eliminates the Orbiter and adds a cargo carrier with the engines in recoverable re-entry pod. We have assessed the potential of replacing the solids with liquid boosters to provide larger Shuttle launch capability. We have studied how to use the volume behind the External Tank as additional launch volume to orbit. We cannot increase the lift capability of the Shuttle but we can take more volume and there are a number of

missions that allow more payload to orbit. This (Figure 28) is a family of cargo vehicles that starts with the Space Shuttle launch systems. Using two SRB's and one or two SSME's behind the External Tank we can delivery 80,000 to 130,000 pounds of payload to orbit. There are not a lot of launches in this category. The few considered are larger in diameter and require more launch capability than the Shuttle capability. The side-mount payload fairing and engine pad replace the Orbiter and deliver 150,000 pounds. A very large capability vehicle utilizes two SSME's in each of two engine pods with two standard SRB's and an External Tank and can delivery 225,000 pounds to LEO. The concept can be expanded by adding more SSME's and solids to deliver 300,000 pounds in low-earth orbit. Figure 29 is an artist picture of a cargo vehicle concept. The Aft Cargo Carrier utilizes the volume behind the External Tank. This doubles the payload volume to orbit. Figure 31 shows some of the missions that could be placed in this volume. An economic advantage can be realized by using this volume, when weight permits. It requires that we take the External Tank to orbit. We have studied how that can be done safely by adding a retrograde package to deorbit the External Tank. We could locate an Orbit Transfer Vehicle in this volume and add greater capability than the Centaur and relieve the dangers involved in handling a hydrogen vehicle in the orbiter payload bay.

The Advanced X-Ray Astrophysics Facility (AXAF), Figures 33 and 34, is a telescope much like the Space Telescope except that its X-ray differs in that the lens of the mirrors are nested instead of flat as Dr. Speer showed for Space Telescope. Nested mirrors are similar to several water glasses inside each other with a very small spacing to allow the X-Ray rays to be reflected slightly to the focal plane. This particular telescope design has the instruments mounted to the front whereas the Space Telescope systems are in the aft end. We have presently accomplished the Phase A study design on the AXAF in-house. We are in the process of doing some technology demonstrations on the mirrors. In fact, we are going to grind one of these nested mirrors to full size to prove that we can manufacture to the curvature and smoothness required for X-ray performance. Dr. Lucas mentioned the High Energy Astronomy Observatory (HEAO) and the important science gained by those spacecraft. Much has been learned about X-rays not previously known concerning quasars, black holes, etc. X-ray astronomy is evolving and has a very sound scientific base.

Finally, Figure 36, Materials Processing in Space - although a busy chart, I want to make two points. Dr. Lucas showed the many ways that we are presently supporting Materials Processing in Space. We are moving into another era, similar to space commercialization of communications. The government spent a lot of money in the early 1960's putting

up the first satellite before the communication industry began to realize the profit potential. Today that modest investment by the government has grown into billions of dollars per year commercial market - similarly with weather satellites. A number of satellite technology studies and demonstrations were done prior to commercial use of weather pictures you see today on TV. In Materials Processing, we are at the threshold. We want commercialization to happen but it will take a little more time. It will take more government expenditures. There is a need to develop a base of science and capability before the private sector will move in on a profit scale similar to communication. I believe materials processing will be much larger because it involves a large number of industries. Presently the most promising application is in pharmaceuticals and McDonnell Douglas and Johnson and Johnson are pioneering the way. There are dollars being invested today by the private sector but we have some additional work to do to make materials processing happen. The Marshall Space Flight Center, (Figure 37) has thrusts in the direction of developing the science base, flight apparatus and commercialization. Dr. Lucas mentioned what we are doing in the science base area and that is very important because we must have the science and the users in order to evolve the ideas for the applications program. We have over fifty principal investigators working on approximately seventy various science projects. These investigations will evolve into applications for the commercial community either as space produced products or

as improvements in ground based processing. Dr. Lucas mentioned a ground base improvement potential, cast iron formation. Flight apparatus development is underway in a number of areas. We have to have laboratories in space to have the time to do experimentation. These scientific apparatuses will allow us to experiment. We are pushing commercialization with joint endeavor agreements and technical exchange agreements. Apparatus that we are currently using is the MEA (Figure 38) which is a Materials Experiment Carrier. This will give us an opportunity to take four experiments at one time to orbit and do experimentation. This is not on the aft flight deck. The MEA is in the cargo bay of the orbiter. Figure 39 shows some research areas that Dr. Lucas showed you on an earlier chart. These are the processes that we are investigating which have a potential. The bars blacked in are our assessment of research progress. We will visit commercial companies that have potential applications from space. We have visited 300-400 specific companies and have shown them the potential for going to space and developing a commercial product.

Finally, Figure 40 shows the electrophoresis experiment which the McDonnell Douglas people are putting together. The program was started at the Marshall Center several years ago. We helped the marriage between Johnson and Johnson and McDonnell Douglas and they are building a potential commercial facility. That completes my presentation.

REPRESENTATIVE LUJAN: Are there any other of these experiments that did go up?

MR. MARSHALL: Yes. Perhaps Jim Downey could address that question.

MR. DOWNEY: We have not had a commercial venture like the electrophoresis. But we flight tested a monodisperse latex reactor system for making very small latex spheres to use in biomedical research. We are investigating that process under weightlessness. There's a whole series of flights planned in the cargo bay of the Shuttle. Of course, the unique capability of the Shuttle to return specimens will accelerate our future experiment progress.

REPRESENTATIVE FLIPPO: Bob, in Materials Processing, could you effectively use more money in a real efficient manner?

MR. MARSHALL: Yes, I believe we can. There are two specific areas where we need more money today. We need to increase our scientific base by adding more science capabilities and we also need to have more experiment apparatus supplied. Both of those are going to be prerequisites for us to move into commercialization.

REPRESENTATIVE FLIPPO: This committee, Mr. Chairman, has had a long history of trying to put more money into the advanced programs because we realize the necessity of really examining new things carefully and trying to define what we

want to do if we are going to be effective in the future. We haven't been too successful in adding additional funds for advanced programs but this subcommittee has always been supportive. I know we don't want to study everything to death but one of the things that it looks to me like we have studied an awful lot is Space Station to Platforms or whatever terminology you want to use. Is Marshall ready to accept that mission and go do that job and get on with it or do we need to keep studying it? What do you think?

MR. MARSHALL: Yes sir, we are ready. We've been honing our skills since the Skylab days. We have done a number of studies and we have a very good understanding of what direction the thrust is.

CHAIRMAN VOLKMER: Have you ever talked to Mr. Keyworth?

MR. MARSHALL: I think that's a good question. I appreciate what Mr. Keyworth says. I would like to discuss with him the need for the first step before we get to total automation.

CHAIRMAN VOLKMER: In other words, if we were playing checkers, it would be somebody else's move, not yours.

MR. MARSHALL: Yes sir. We're ready to go.

CHAIRMAN VOLKMER: In other words, you could use more money in the Space Station application?

MR. MARSHALL: To lay it on the line, that's right.

CHAIRMAN VOLKMER: Thank you very much.

[Figures 1-40 of William Marshall's oral presentation, plus his prepared statement follow:]

MSFC PROGRAM/PROJECT ACTIVITY

2/23/83

APPROVED FOR IMPLEMENTATION	ASSIGNED FOR DEFINITION	PROPOSED FOR FUTURE
• SPACE SHUTTLE – MAIN ENGINE – EXTERNAL TANK – SOLID ROCKET BOOSTER – SYSTEMS ANALYSIS, TEST & INTEGRATION	• TRANSFER ORBIT STAGE	• SHUTTLE DERIVED VEHICLES • SPACE STATION
• STS OPERATIONS		• GEOSTATIONARY PLATFORM
• INERTIAL UPPER STAGE		• ORBITAL TRANSFER VEHICLE
• SPACELAB	• TETHERED SATELLITE SYSTEM	• TELEOPERATOR MANEUVERING SYSTEM
• SPACELAB P/L MISSION MGMT		• DEPLOYABLE ANTENNA FLIGHT EXPERIMENT
• MATERIALS PROCESSING – EXPERIMENT DEVELOPMENT – PRECURSOR EXPERIMENTS – SPACE SHUTTLE PAYLOADS	• SPACE PLATFORM • ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)	• LARGE SPACE STRUCTURES ENGINEERING • SOLAR TERRESTRIAL OBSERVATORY
• SPACE TELESCOPE		• PIN HOLE OCCULTER
• FLIGHT EXPERIMENT	• GRAVITY PROBE B (GP–B)	• ADVANCED SOLAR OBSERVATORY
• SUPPORTING RESEARCH AND TECHNOLOGY		

FIGURE 1

AGENDA

- SPACE STATION/PLATFORM
- TRANSFER ORBIT STAGE
- TELEOPERATOR MANEUVERING SYSTEM
- ORBIT TRANSFER VEHICLE
- SHUTTLE DERIVED VEHICLES
- AFT CARGO CARRIER
- ADVANCED X-RAY ASTROPHYSICS FACILITY
- MATERIALS PROCESSING IN SPACE

FIGURE 2

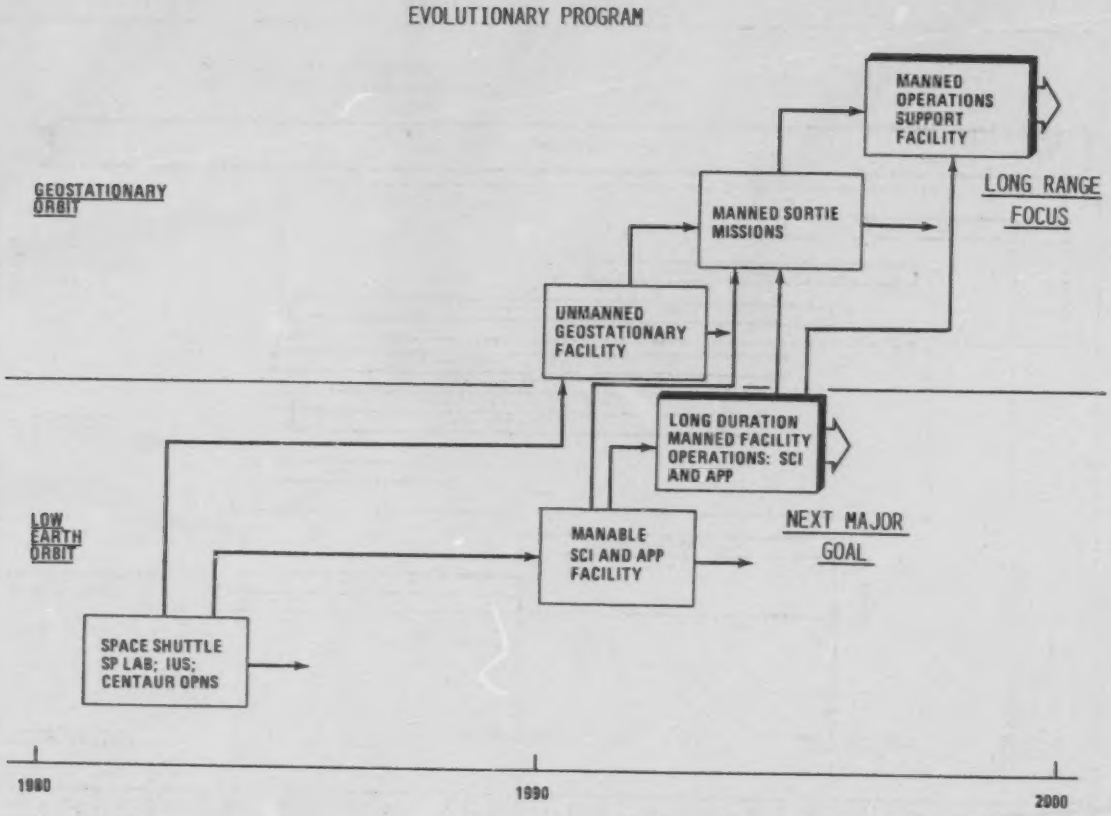
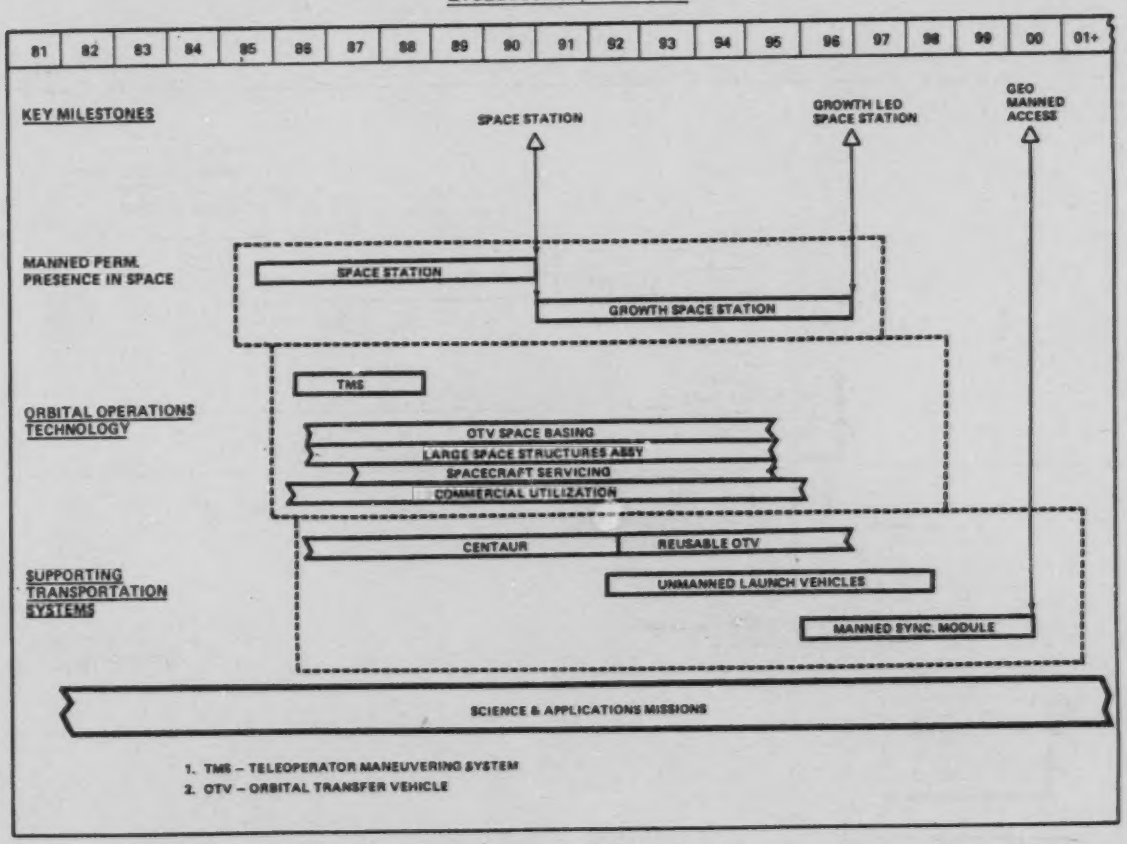

EVOLUTIONARY PROGRAM
MANNED OPERATIONS SUPPORT FACILITY
GEOSTATIONARY ORBIT
LONG RANGE FOCUS
MANNED SORTIE MISSIONS
UNMANNED GEOSTATIONARY FACILITY
LONG DURATION MANNED FACILITY OPERATIONS: SCI AND APP
LOW EARTH ORBIT
NEXT MAJOR GOAL
MANABLE SCI AND APP FACILITY
SPACE SHUTTLE SP LAB; IUS; CENTAUR OPNS
1980
1990
2000
TIME

FIGURE 3


EVOLUTIONARY PROGRAM
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01+
KEY MILESTONES
SPACE STATION
GROWTH LEO SPACE STATION
GEO MANNED ACCESS
MANNED PERM. PRESENCE IN SPACE
SPACE STATION
GROWTH SPACE STATION
ORBITAL OPERATIONS TECHNOLOGY
TMS
OTV SPACE BASING
LARGE SPACE STRUCTURES ASSY
SPACECRAFT SERVICING
COMMERCIAL UTILIZATION
SUPPORTING TRANSPORTATION SYSTEMS
CENTAUR
REUSABLE OTV
UNMANNED LAUNCH VEHICLES
MANNED SYNC. MODULE
SCIENCE & APPLICATIONS MISSIONS
1. TMS – TELEOPERATOR MANEUVERING SYSTEM
2. OTV – ORBITAL TRANSFER VEHICLE

FIGURE 4

0662-83

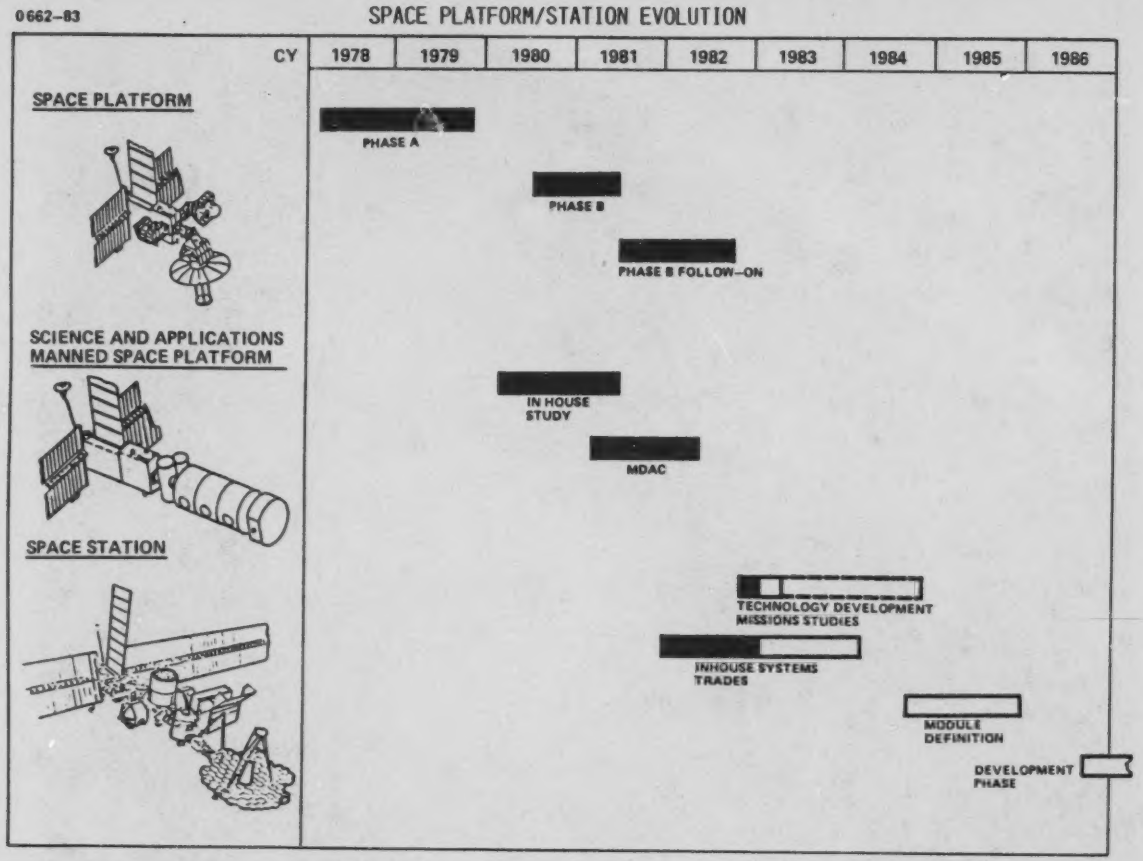

FIGURE 5

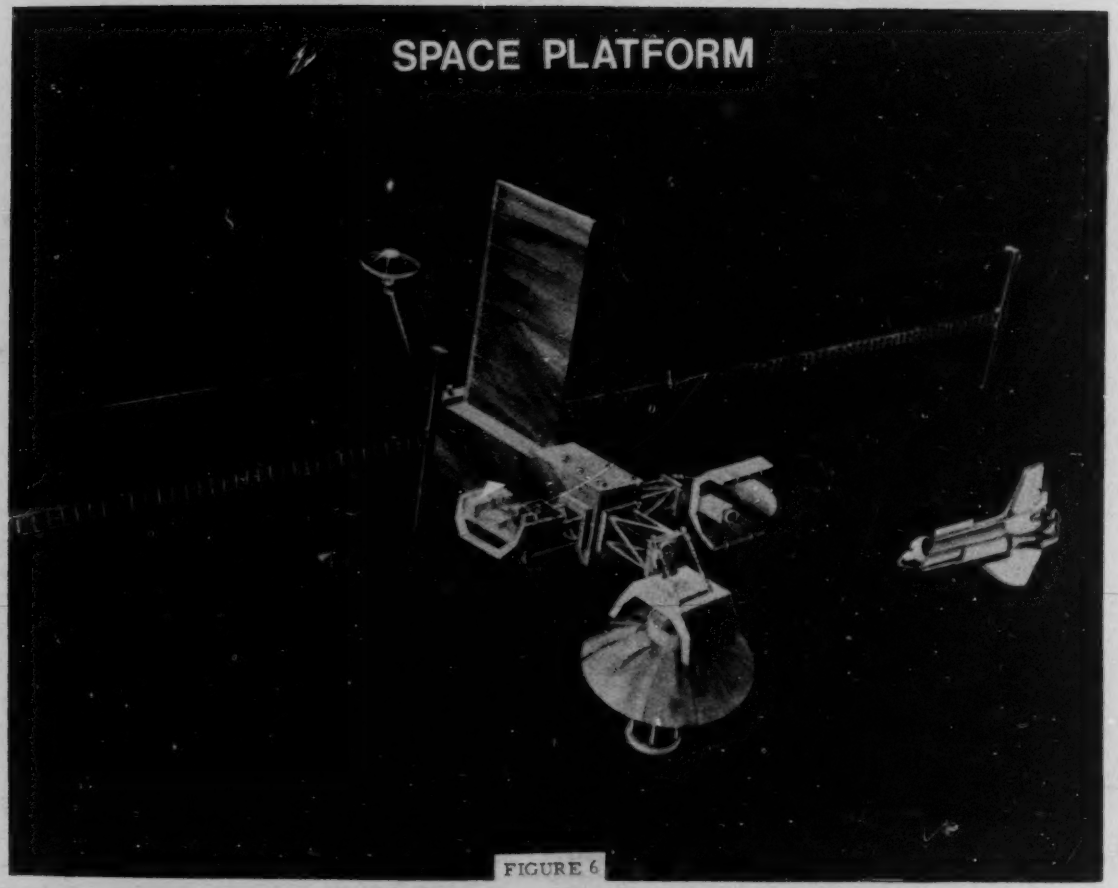

FIGURE 6

FIGURE 7

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SPACE STATION ACTIVITIES

CONTRACTED

MISSION ANALYSIS STUDIES

- (BOEING)
- (GENERAL DYNAMICS)
- (GRUMMAN)
- (LOCKHEED)
- (McDONNELL DOUGLAS)
- (MARTIN MARIETTA)
- (ROCKWELL)
- (TRW)

TECHNOLOGY DEVELOPMENT MISSIONS CONTRACTS

- LARGE SPACE STRUCTURES (BOEING)
- SATELLITE SERVICING (MARTIN MARIETTA)
- OTV SERVICING (GENERAL DYNAMICS)

IN–HOUSE – MSFC

- **SYSTEMS ENGINEERING DEFINITION**
  - MISSION REQUIREMENTS
  - ARCHITECTURE CONCEPTS
- **ADVANCED DEVELOPMENT "TEST BEDS"**
  - OPERATING AND DATA MANAGEMENT SYSTEM
  - ELECTRICAL POWER SYSTEM
  - ON–ORBIT CONTROL SYSTEM – GUIDANCE, NAVIGATION, AND CONTROL
  - ON–ORBIT CONTROL SYSTEM – PROPULSION
  - THERMAL CONTROL SYSTEM
  - SPACE OPERATIONS MECHANISMS
  - STRUCTURAL DYNAMICS AND CONTROL
  - COMMUNICATION AND TRACKING SYSTEMS
  - MAN SYSTEMS – HUMAN CAPABILITIES

1134

FIGURE 8

SPACE STATION
PROGRAM DESCRIPTION DOCUMENTS
("YELLOW BOOKS")

BOOK 1. - INTRODUCTION/SUMMARY

BOOK 2. - MISSION DESCRIPTION

BOOK 3. - SYSTEM REQUIREMENTS AND CHARACTERISTICS

BOOK 4. - TECHNOLOGY OPTIONS

✓**BOOK 5. - SYSTEMS DEFINITION**

- SYSTEM TRADES AND PERFORMANCE ENVELOPE
- ARCHITECTURE
- CONFIGURATIONS

BOOK 6. - SYSTEMS OPERATIONS

BOOK 7. - PROGRAM PLAN

- MANAGEMENT STRUCTURE
- PROCUREMENT
- COST/SCHEDULE

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FIGURE 9

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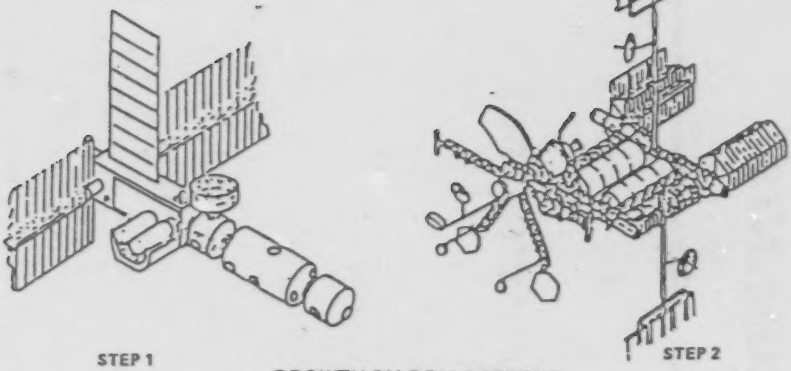
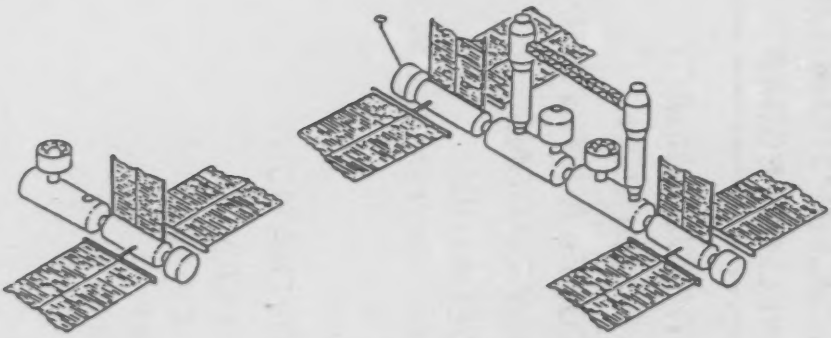
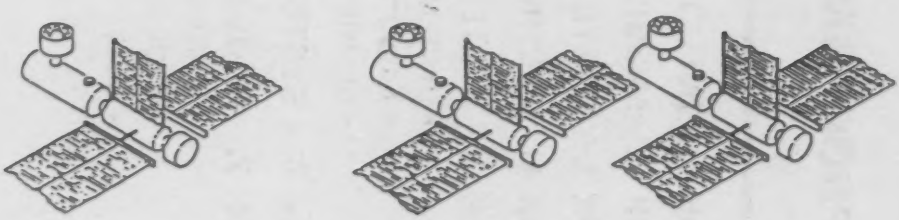


GROWTH BY REPLACEMENT



GROWTH BY EVOLUTION



GROWTH BY REPLICATION

FIGURE 10

AGENDA

SPACE STATION/PLATFORM

TRANSFER ORBIT STAGE

TELEOPERATOR MANEUVERING SYSTEM

ORBIT TRANSFER VEHICLE

SHUTTLE DERIVED VEHICLES

AFT CARGO CARRIER

ADVANCED X-RAY ASTROPHYSICS FACILITY

MATERIALS PROCESSING IN SPACE

FIGURE 15

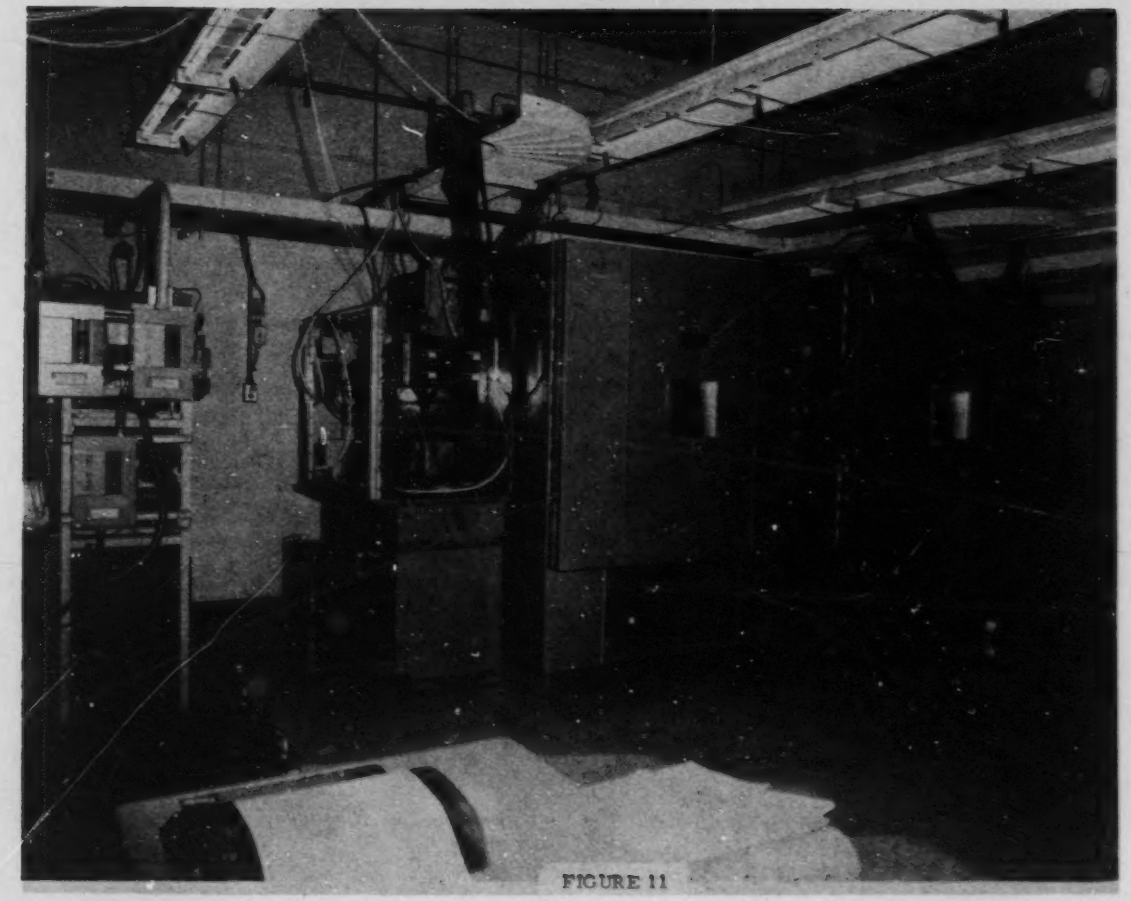
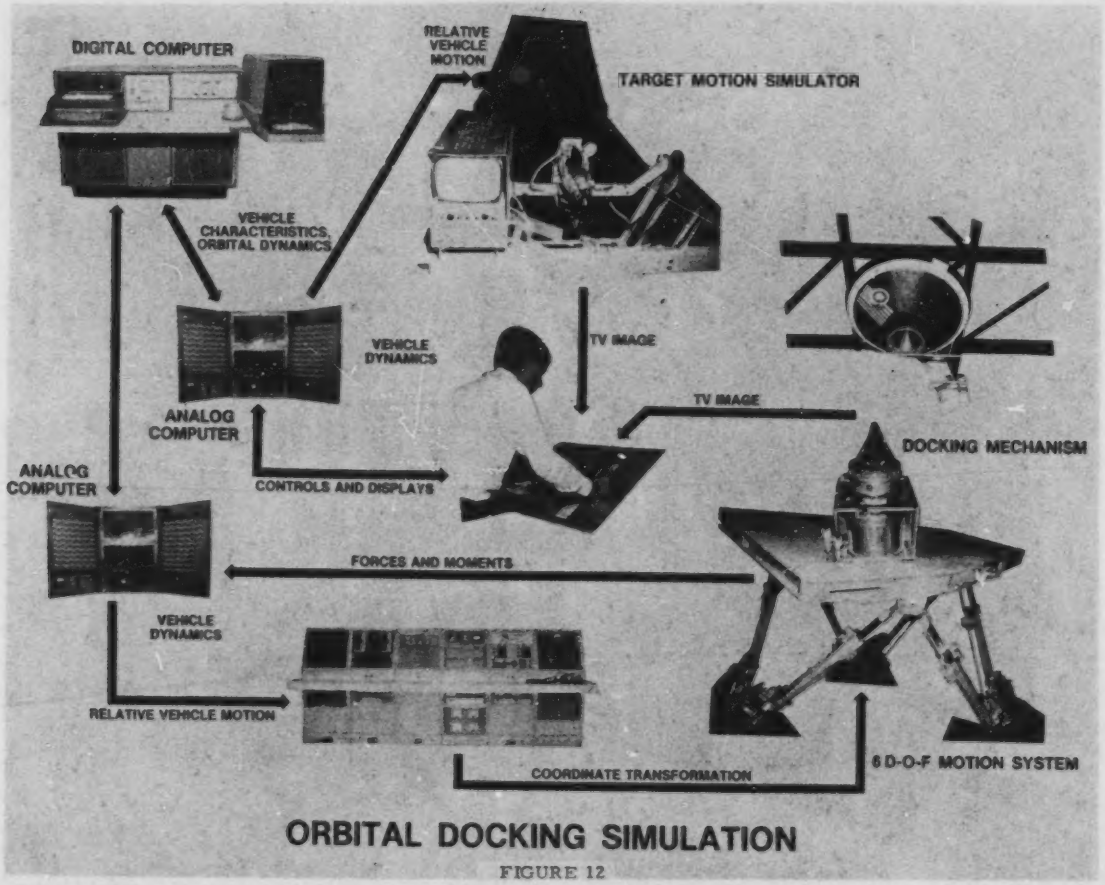


FIGURE 11



ORBITAL DOCKING SIMULATION

FIGURE 12

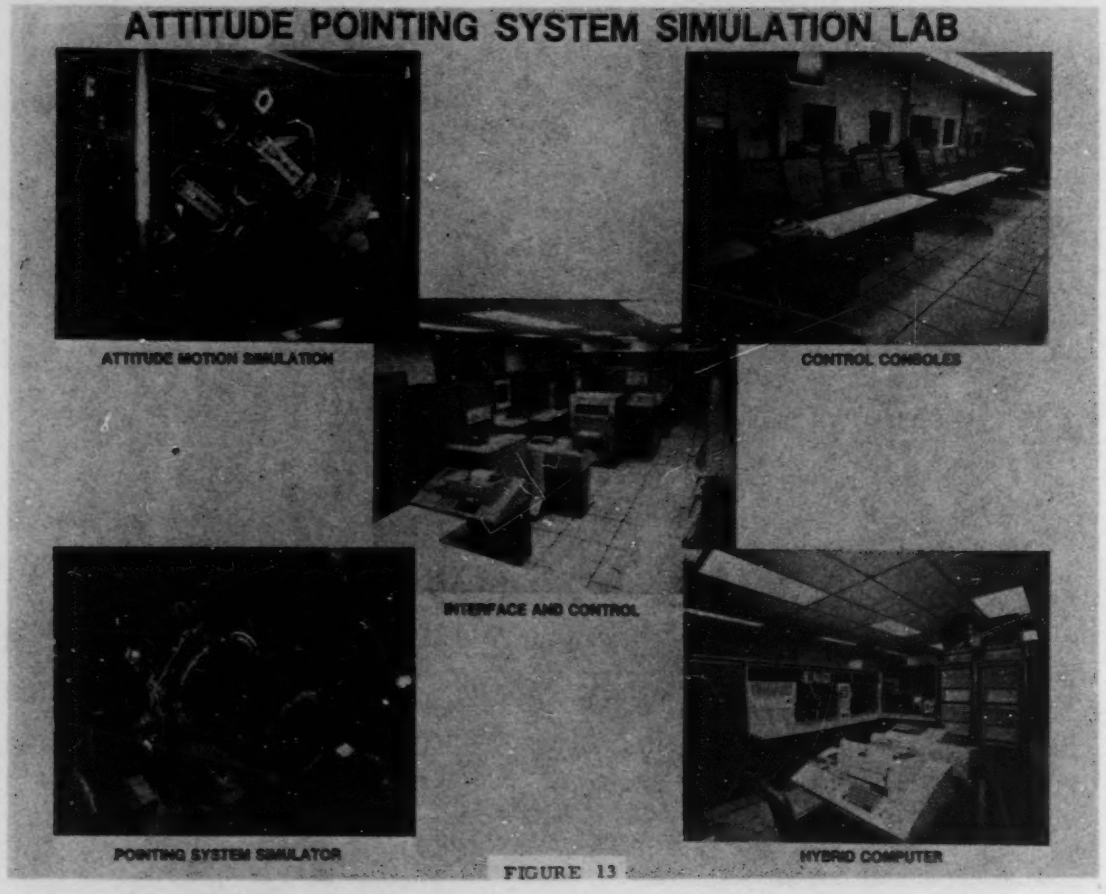

ATTITUDE POINTING SYSTEM SIMULATION LAB
ATTITUDE MOTION SIMULATION
CONTROL CONSOLES
INTERFACE AND CONTROL
POINTING SYSTEM SIMULATOR
HYBRID COMPUTER

FIGURE 13

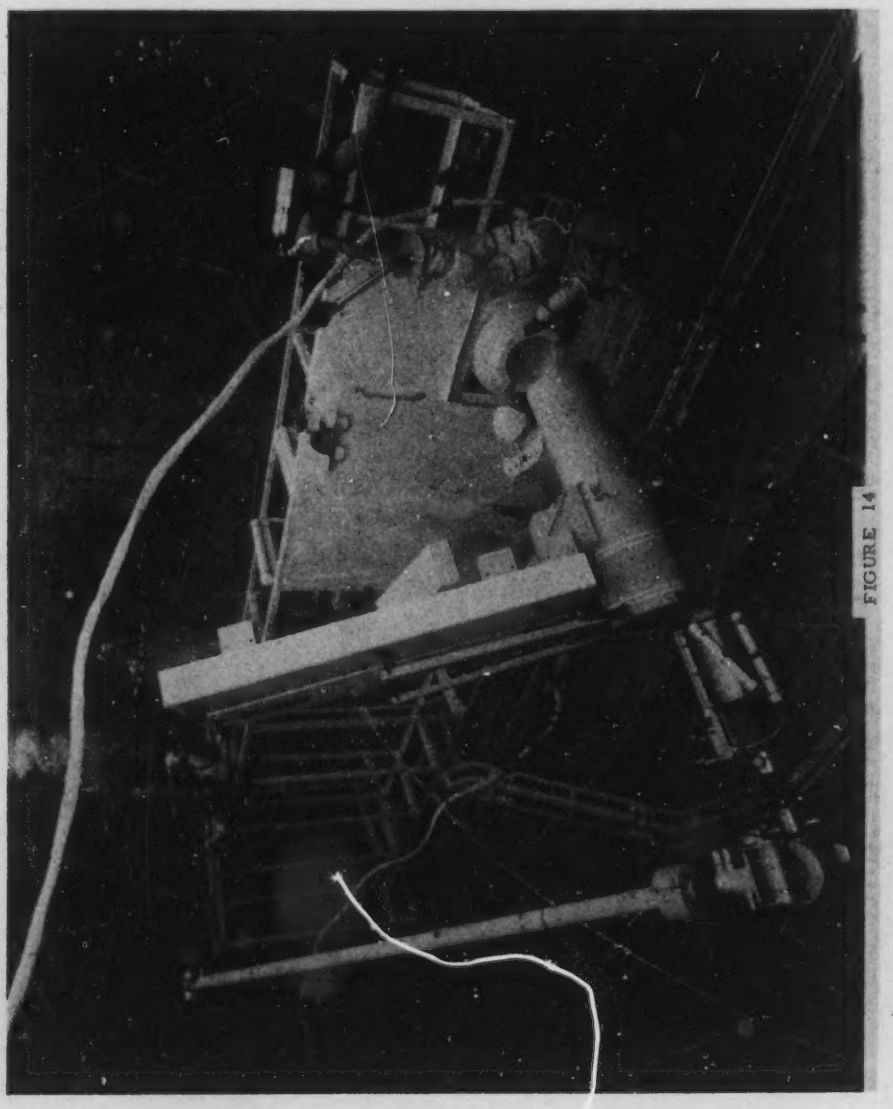
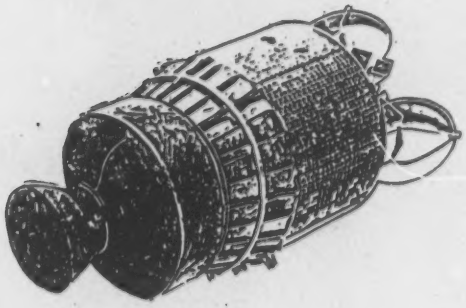
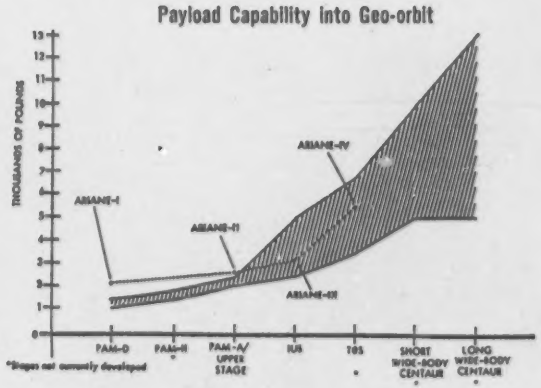


FIGURE 14

TRANSFER ORBIT STAGE





COMMERCIAL COMMITMENT

- ORBITAL SYSTEMS CORPORATION/ MARTIN-MARIETTA CORPORATION
- THE BOEING COMPANY

FIGURE 16

AGENDA

- SPACE STATION/PLATFORM
- TRANSFER ORBIT STAGE
- TELEOPERATOR MANEUVERING SYSTEM
- ORBIT TRANSFER VEHICLE
- SHUTTLE DERIVED VEHICLES
- AFT CARGO CARRIER
- ADVANCED X-RAY ASTROPHYSICS FACILITY
- MATERIALS PROCESSING IN SPACE

FIGURE 17

AGENDA

- SPACE STATION/PLATFORM
- TRANSFER ORBIT STAGE
- TELEOPERATOR MANEUVERING SYSTEM
- ORBIT TRANSFER VEHICLE
- SHUTTLE DERIVED VEHICLES
- AFT CARGO CARRIER
- ADVANCED X-RAY ASTROPHYSICS FACILITY
- MATERIALS PROCESSING IN SPACE

FIGURE 22

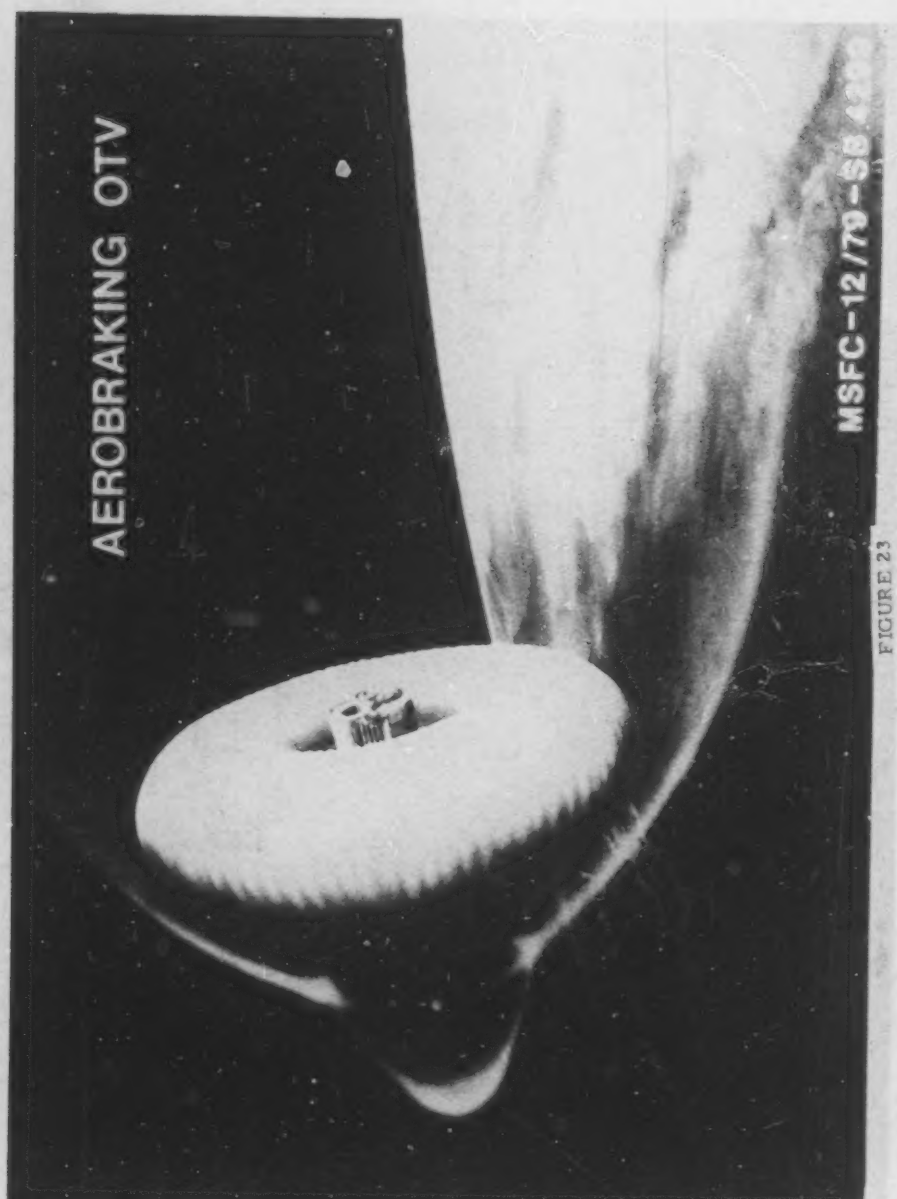


FIGURE 23

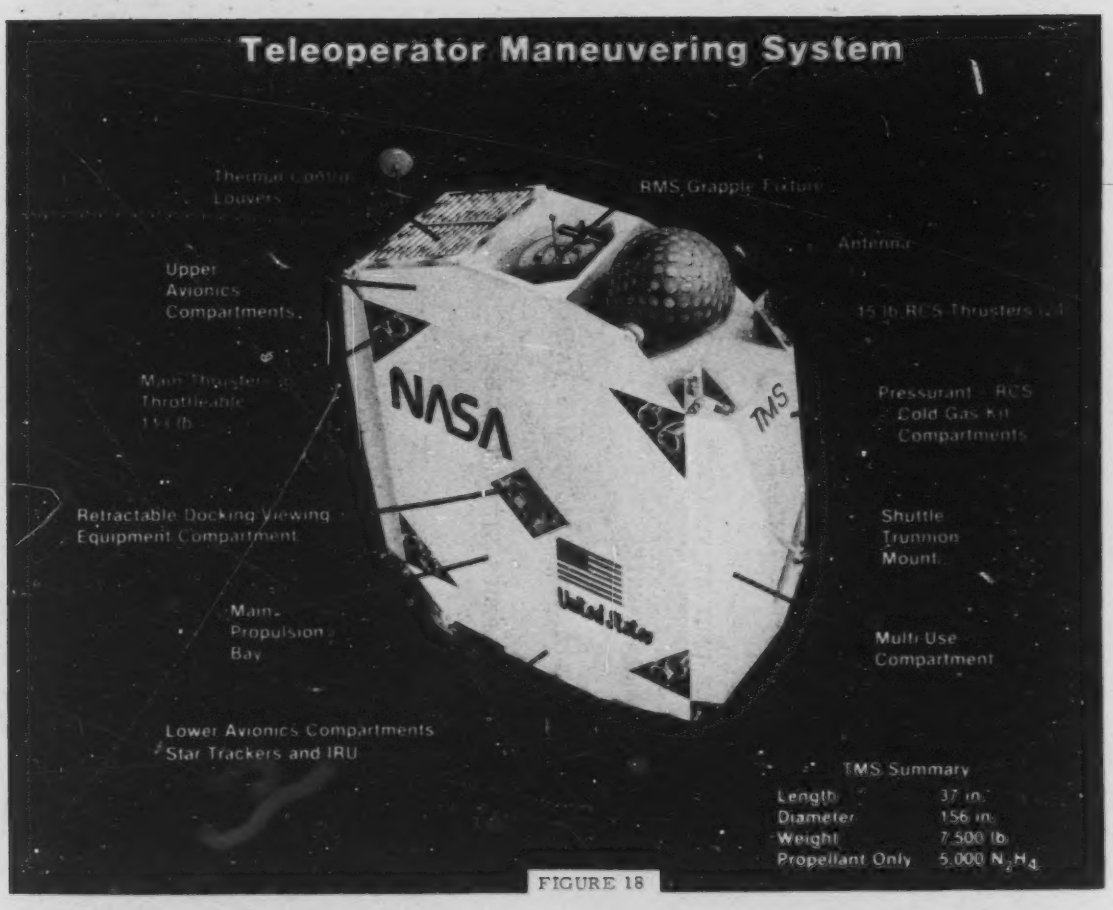

Teleoperator Maneuvering System
Thermal Control Louvers
RMS Grapple Fixture
Antenna
Upper Avionics Compartments
15 lb RCS Thrusters (12)
Main Thrusters (2) Throttleable 1500 lb
Pressurant RCS Cold Gas Kit Compartments
NASA
TMS
Retractable Docking Viewing Equipment Compartment
Shuttle Trunnion Mount
Main Propulsion Bay
Multi-Use Compartment
Lower Avionics Compartments Star Trackers and IRU
TMS Summary
Length 37 in.
Diameter 156 in.
Weight 7,500 lb
Propellant Only 5,000 N_2H_4

FIGURE 18

TELEOPERATOR MANEUVERING SYSTEM (TMS) APPLICATIONS

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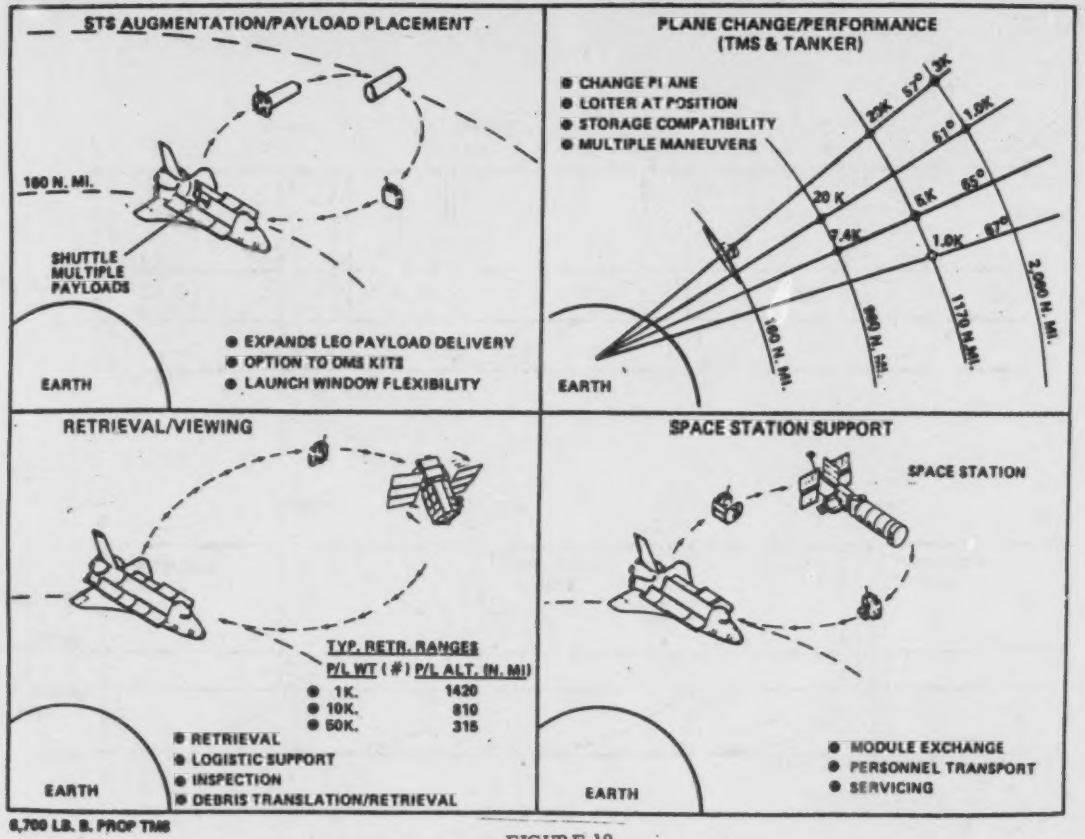


6,700 LB. B. PROP TMS

FIGURE 19

TWO AXAF MISSION SCENARIOS (TYPICAL)

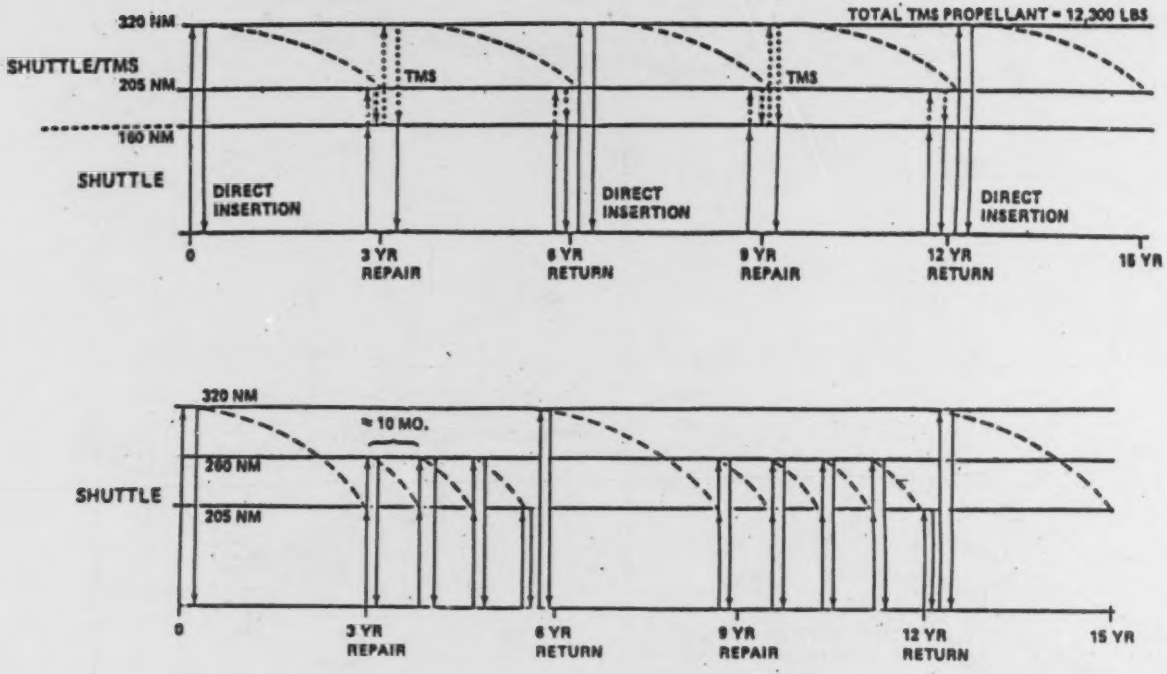


FIGURE 20

TELEOPERATOR MANEUVERING SYSTEM (TMS)

- TMS IS A REMOTELY CONTROLLED, FREE-FLYING, ORBITAL MINI-TUG VEHICLE CAPABLE OF PERFORMING A WIDE RANGE OF REMOTE SATELLITE SERVICES MISSIONS

- TMS ENHANCES THE ORBITER'S CAPABILITY & EFFICIENCY:
  - DELIVERY TO OR RETRIEVAL OF PAYLOADS FROM HIGH ALTITUDE ORBITS
  - MANEUVERING OR REPOSITIONING (PLANE CHANGE) OF P/L'S
  - SUPPORTS P/L'S FOR LONG DURATION ORBITAL STORAGE MISSIONS
  - REMOTE P/L VIEWING (TV), REFUELING; SERVICING; SPACE STATION SUPPORT
  - PERMITS EFFICIENT CO-MANIFESTING OF P/L'S ASSIGNED TO DIFFERENT ALTITUDES (MAXIMIZES USE OF STS CARGO DELIVERY CAPABILITY TO LEO)

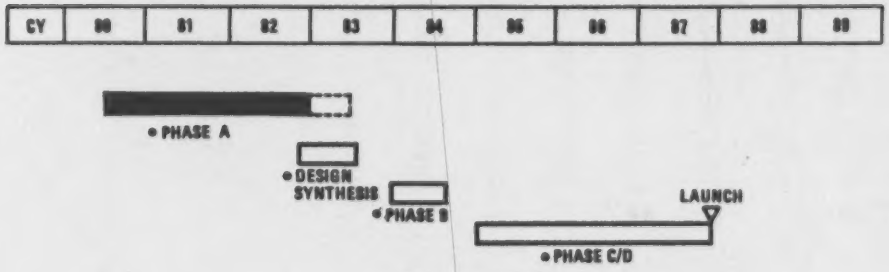


FIGURE 21

AGENDA

SPACE STATION/PLATFORM

TRANSFER ORBIT STAGE

TELEOPERATOR MANEUVERING SYSTEM

ORBIT TRANSFER VEHICLE

SHUTTLE DERIVED VEHICLES

AFT CARGO CARRIER

ADVANCED X-RAY ASTROPHYSICS FACILITY

MATERIALS PROCESSING IN SPACE

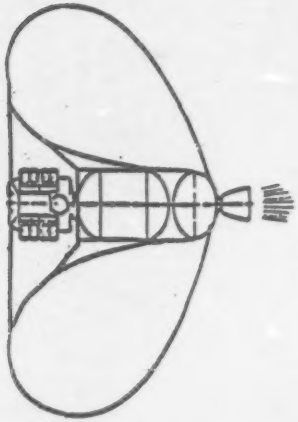
FIGURE 26

AGENDA

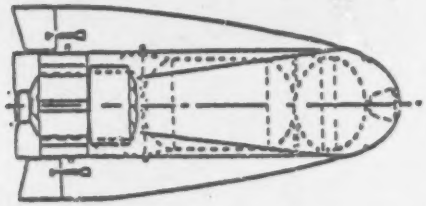
- SPACE STATION/PLATFORM
- TRANSFER ORBIT STAGE
- TELEOPERATOR MANEUVERING SYSTEM
- ORBIT TRANSFER VEHICLE
- SHUTTLE DERIVED VEHICLES
- AFT CARGO CARRIER
- ADVANCED X-RAY ASTROPHYSICS FACILITY
- MATERIALS PROCESSING IN SPACE

FIGURE 30

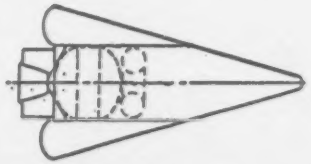
CONCEPTS OF AEROASSISTED RETURN



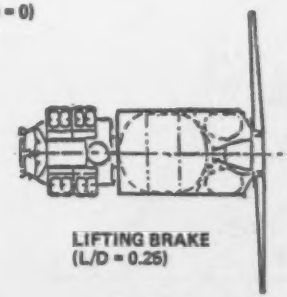
BALLUTE (L/D = 0)



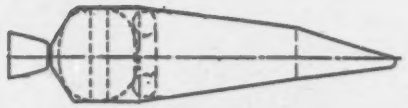
AEROMANEUVERING (L/D = 0.85)



WINGED (L/D = 2.0)



LIFTING BRAKE
(L/D = 0.25)



BICONIC
(L/D = 1.5)

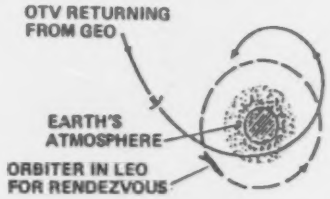
FIGURE 24

AEROASSISTED OTV

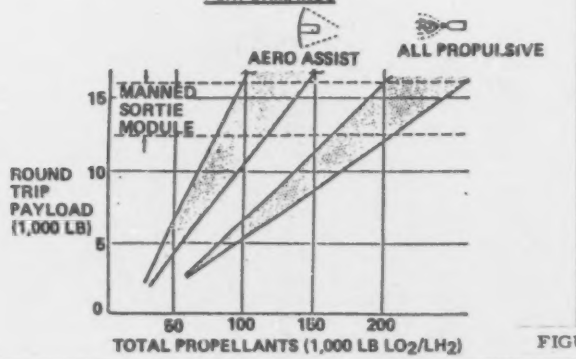
RATIONALE

- FACILITATES MANNED GEO ACCESS
- ENHANCES SPACE BASING THRU REUSABILITY
- PERMITS PAYLOAD RETURN/RETRIEVAL
- ENABLES HIGH PLANE CHANGE MISSIONS

MISSION MODE



PERFORMANCE



AEROASSIST TECHNOLOGY WORKING GROUP

CO–CHAIRMEN: MSFC, AFWAL

MEMBERS:	NASA	DOD
	MSFC	AFWAL
	JPL	ED
	LARC	RPL
	ARC	
	LERC	
	JSC	

PURPOSE: TO IDENTIFY AND PRIORITIZE TECHNOLOGY REQUIREMENTS FOR FUTURE AEROASSISTED ORBITAL TRANSFER VEHICLES

FIGURE 25

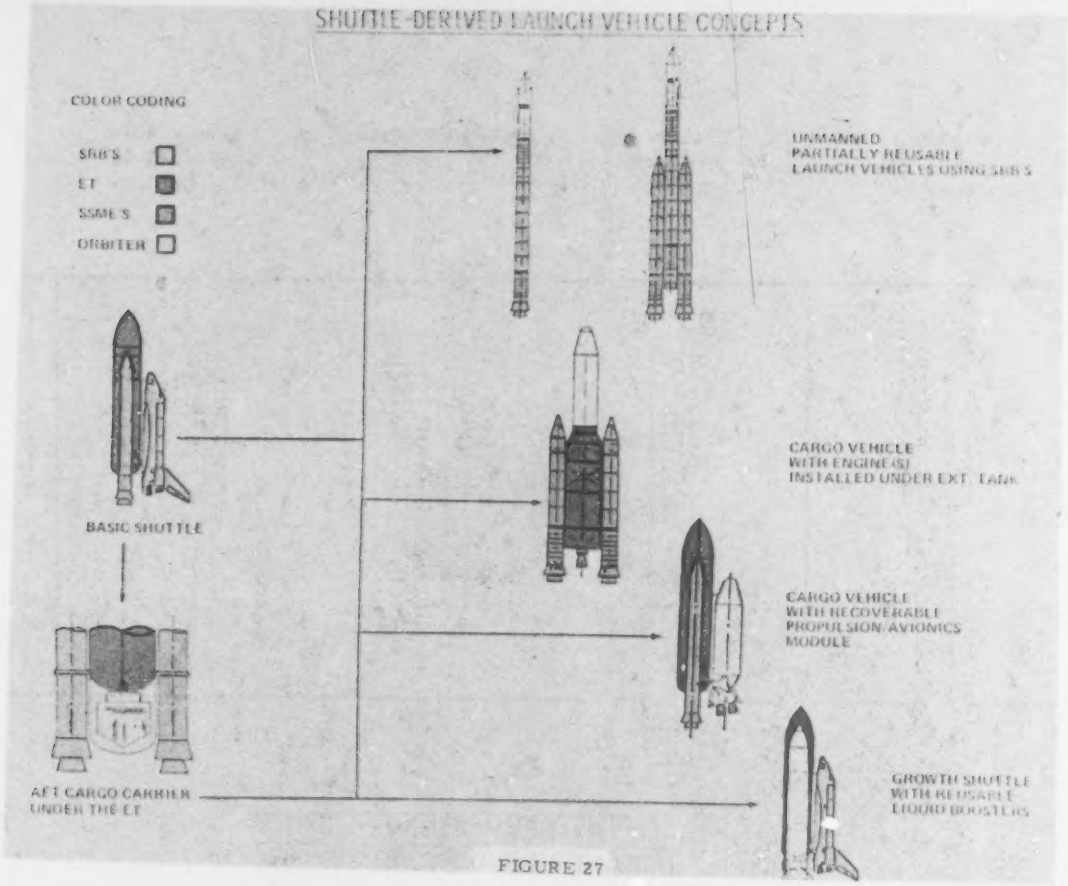
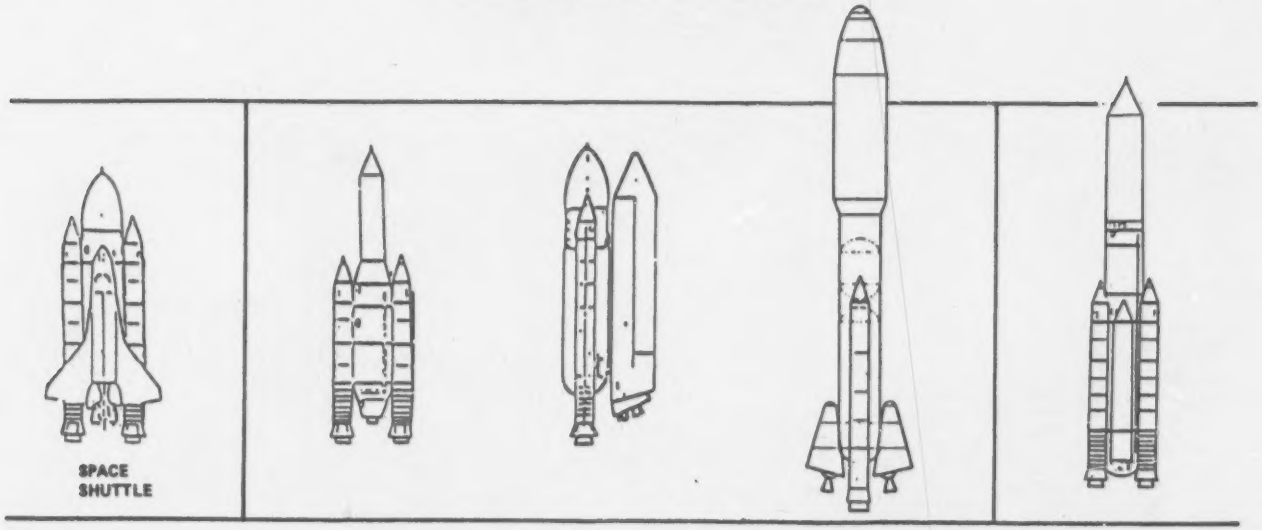

SHUTTLE-DERIVED LAUNCH VEHICLE CONCEPTS
COLOR CODING
SRB'S
ET
SSME'S
ORBITER
BASIC SHUTTLE
AFT CARGO CARRIER
UNDER THE ET
UNMANNED
PARTIALLY REUSABLE
LAUNCH VEHICLES USING SRB'S
CARGO VEHICLE
WITH ENGINE(S)
INSTALLED UNDER EXT. TANK
CARGO VEHICLE
WITH RECOVERABLE
PROPULSION/AVIONICS
MODULE
GROWTH SHUTTLE
WITH REUSABLE
LIQUID BOOSTERS

FIGURE 27

SHUTTLE-DERIVED CARGO VEHICLE (SDCV) VEHICLE OPTIONS/CAPABILITIES



• 2 X SRB • 3 X SSME • 65K PLD.	• 2 X SRB • 1 OR 2 X SSME • 80K–150K PLD.	• 2 X SRB • 3 X SSME • 150K–200K PLD.	• 2 X SRB • 4 X SSME • 247K PLD.	• 4 X SRB • 5 X SSME • 300K PLD.

FIGURE 28

FIGURE 29

AGENDA

SPACE STATION/PLATFORM

TRANSFER ORBIT STAGE

TELEOPERATOR MANEUVERING SYSTEM

ORBIT TRANSFER VEHICLE

SHUTTLE DERIVED VEHICLES

AFT CARGO CARRIER

▶ ADVANCED X-RAY ASTROPHYSICS FACILITY

MATERIALS PROCESSING IN SPACE

FIGURE 32

AGENDA

SPACE STATION/PLATFORM

TRANSFER ORBIT STAGE

TELEOPERATOR MANEUVERING SYSTEM

ORBIT TRANSFER VEHICLE

SHUTTLE DERIVED VEHICLES

AFT CARGO CARRIER

ADVANCED X-RAY ASTROPHYSICS FACILITY

MATERIALS PROCESSING IN SPACE

FIGURE 35

0710-83

MSFC'S THRUST IN MPS

- DEVELOPMENT OF SCIENCE BASE
  - INHOUSE RESEARCH/DEVELOPMENT CAPABILITY
  - OVER FIFTY CONTRACTED PRINCIPAL INVESTIGATORS
- FLIGHT HARDWARE DEVELOPMENT
  - MATERIALS EXPERIMENT ASSEMBLY
  - EXPERIMENT APPARATUS
  - GROUND SIMULATION FACILITIES
- COMMERCIALIZATION OF MPS
  - JOINT ENDEAVOR AGREEMENTS
  - TECHNICAL EXCHANGE AGREEMENTS

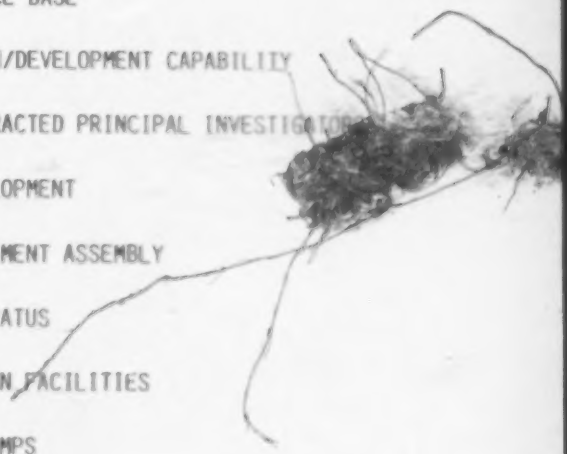


FIGURE 37

THE AFT CARGO CARRIER PROVIDES A MAJOR ENHANCEMENT TO THE BASIC STS

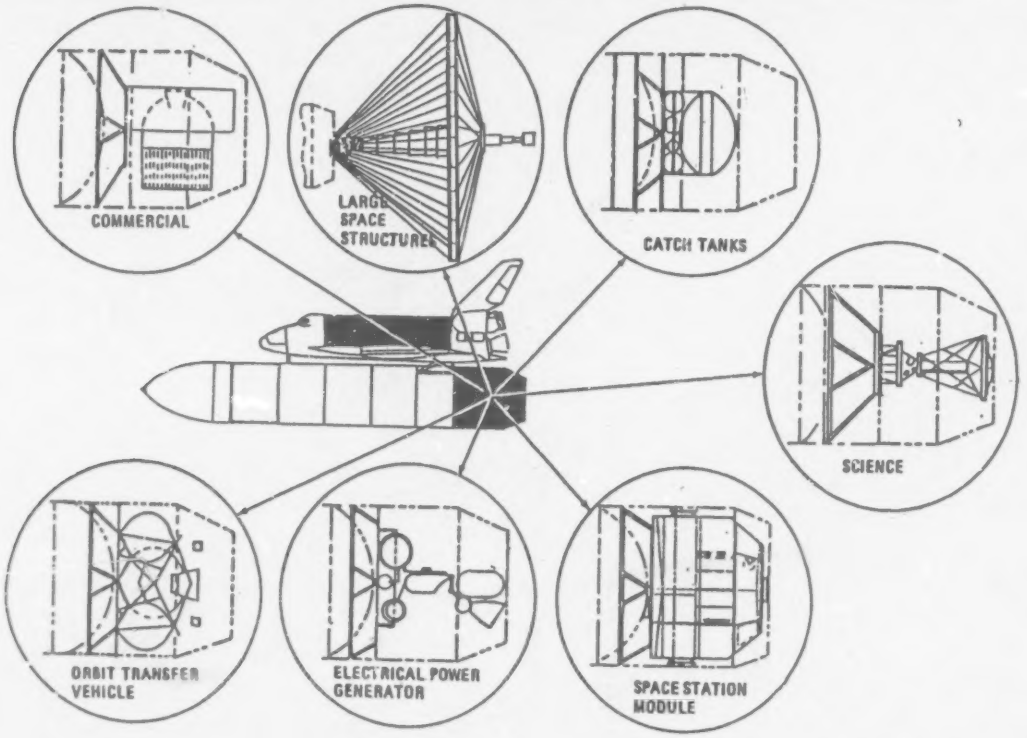


FIGURE 31

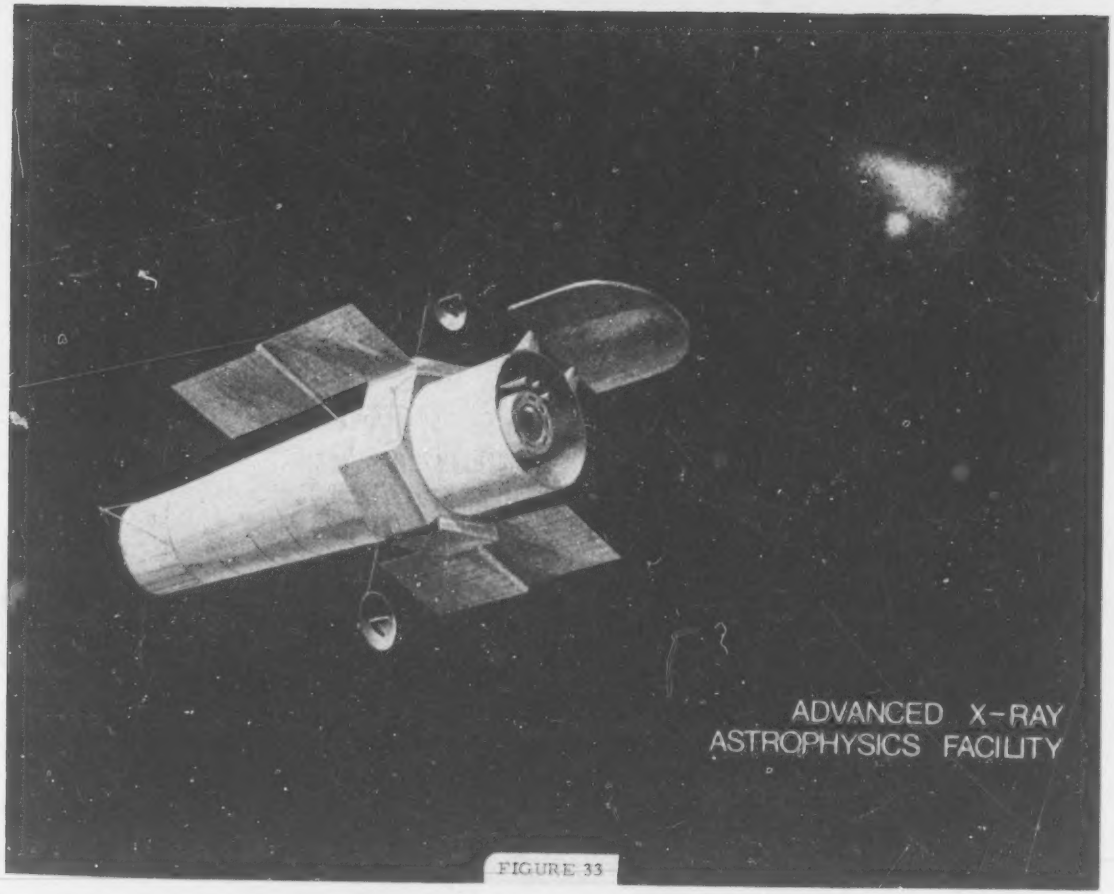


FIGURE 33

ADVANCED X-RAY ASTROPHYSICS FACILITY (AXAF)

X-RAY ASTRONOMY GREATLY ADVANCED BY HEAO

- OBSERVED THOUSANDS OF NEW OBJECTS
- DEMONSTRATED IMPORTANCE OF IMAGE-FORMING X-RAY OPTICS
- INVOLVED HUNDREDS OF SCIENTISTS THROUGHOUT THE WORLD

AXAF WILL PROVIDE:

- IMPROVED ANGULAR RESOLUTION NEEDED FOR DETAILED STUDIES OF SOURCE STRUCTURE
- 100-FOLD INCREASE IN SENSITIVITY WITH IMPROVED ENERGY COVERAGE
- LONG LIFETIME BY USE OF SHUTTLE FOR LAUNCH, REFURBISHMENT, UPDATE AND RETRIEVAL

AXAF ACTIVITIES

- TECHNOLOGY PROGRAM FOR POLISHING, FABRICATION, ASSEMBLY AND TESTING OF LARGE X-RAY MIRRORS
  - TEST FLATS MEASUREMENT PROGRAM
  - MANAGEMENT OF TECHNOLOGY MIRROR ASSEMBLY CONTRACTS
- PREPARATIONS FOR PHASE B RFP

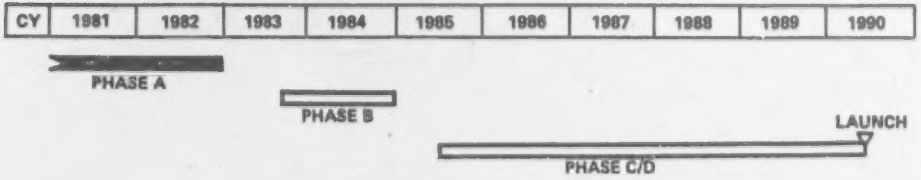


FIGURE 34

174-82

U. S. SPACE PROGRAM

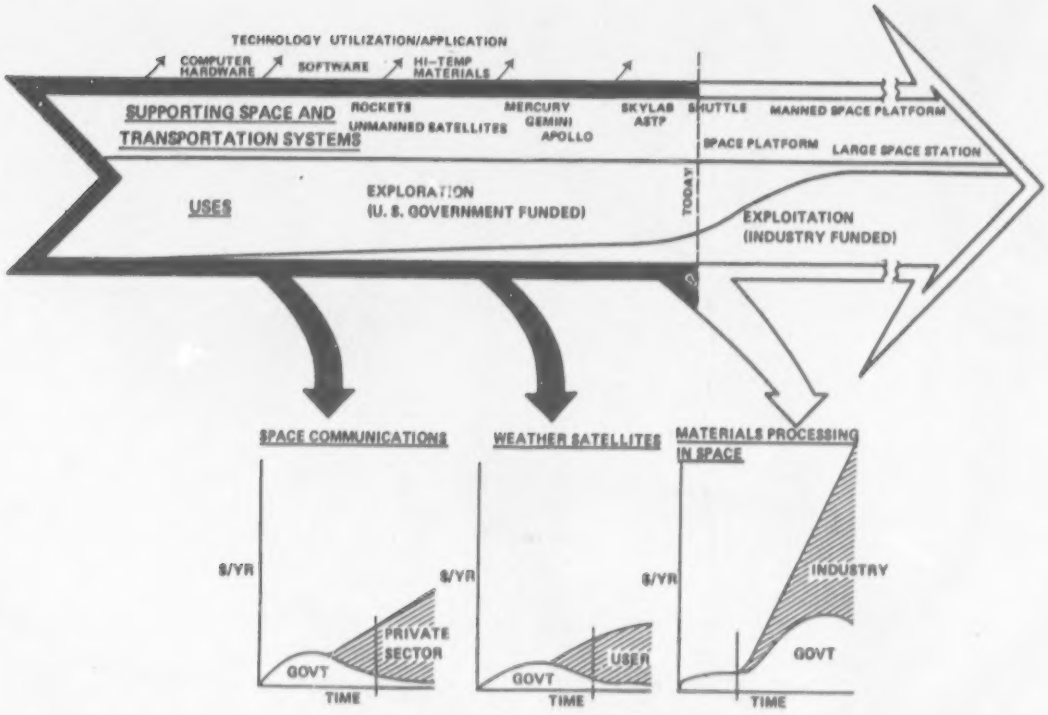


FIGURE 36

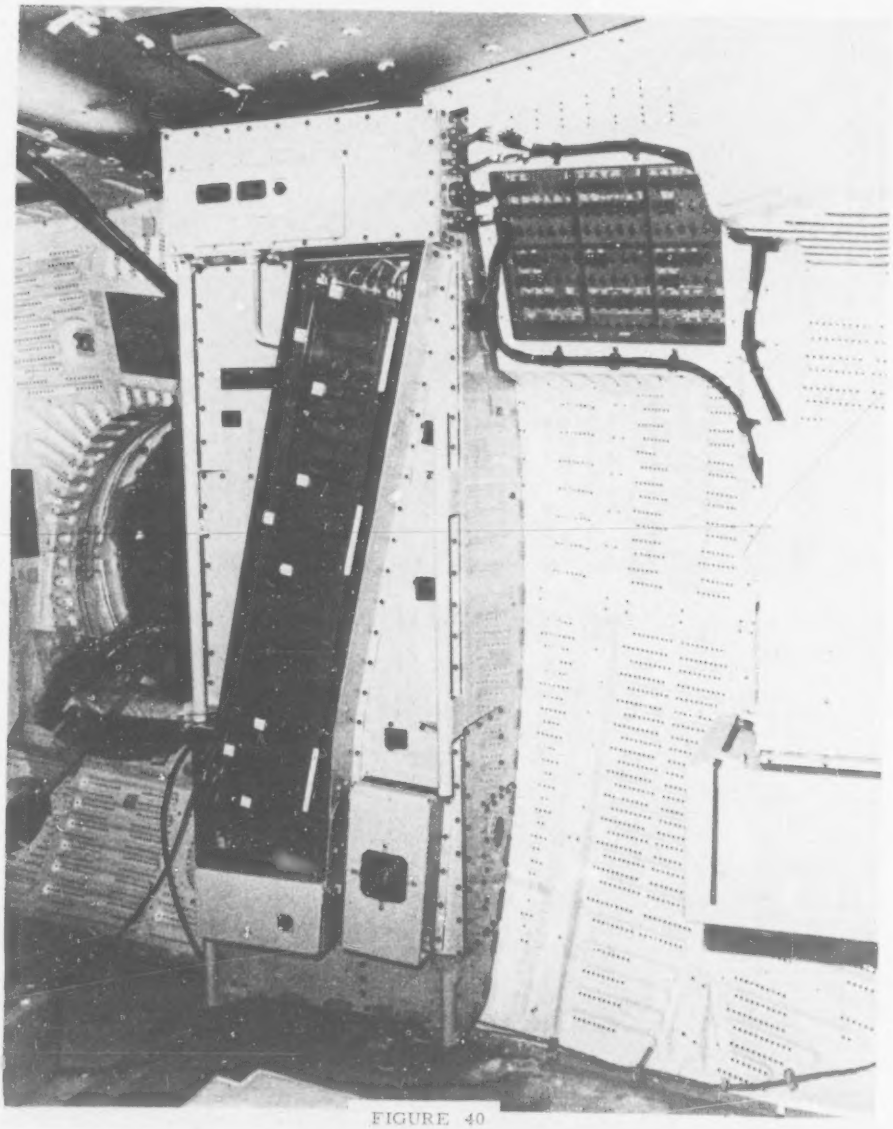


FIGURE 40

STATEMENT

OF

MR. WILLIAM R. MARSHALL
DIRECTOR

PROGRAM DEVELOPMENT
MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Subcommittee:

Last year's testimony to this subcommittee described three broad areas of the Marshall Space Flight Center's (MSFC) advanced planning activities -- Space Platforms and Large Structures, Advanced Transportation Systems, and Science and Applications Payloads. During the past year, efforts have been focused toward Space Station definition activities. This year's testimony also includes a discussion of the Commercial Materials Processing in Space activity which has now been transferred to the Program Development Directorate.

In the planning and analysis for potential permanent manned presence in space, MSFC is taking a broad program view. The total system would include both manned and unmanned elements. This sytem would not only provide permanent presence in orbit but would provide other capabilities that would help realize the great potential of space for a variety of science, applications, national security, and commercial programs. Planning efforts concerned with permanent manned presence in space have received major emphasis during the past year.

SPACE STATION/PLATFORM AND LARGE STRUCTURES

Through the attainment of operational status by the Shuttle, the Space Transportation System (STS), has successfully completed one more step toward the Nation's eventual goal - the permanent presence of man in space. The next logical step is the development of a Manned Space Station that could be the core element for establishing and maintaining this presence. Such a facility, along with the Space Shuttle, would dramatically improve our capabilities to operate in space. The fundamental theme of MSFC's Large Space Structures program encompasses analysis, ground hardware fabrication and test, flight hardware fabrication, and orbital flight readiness tests (where required). These demonstrated and proven techniques will then be applied to systems like the Space Station/Platform and Geosynchronous Communications Platform.

Space Station/Platform - Last year MSFC completed the Space Platform Phase B definition and design studies. Evolution studies were conducted as shown in Figure 1, which showed how a Space Platform, by utilizing Shuttle/Spacelab systems and subsystems, would enable a transition from the Spacelab sortie mode of manned operations to a free-flying Manned Space Platform (MSP). The concepts derived from these studies are still viable and consistent with the current Space Station study activities.

In May 1982, a Space Station Task Force was established by NASA Headquarters to direct the Agency's space station planning activities. The Task Force formed three working groups (Mission Requirements; Systems; and Program Planning) to carry out its responsibilities. MSFC established a Space Station Project Office to interface with the Task Force and other Centers and to direct space station definition and analyses activities within MSFC.

As mentioned above, in studying a potential space station and its capabilities, MSFC is taking a broad program view. We are considering the concept of a comprehensive space system, including Space Station, Teleoperator Maneuvering System, Free-Flying Satellites, Platforms, and Orbit Transfer Vehicles in space. This system could be deployed at different orbits. A space station could be utilized in key operations which would require a manned presence in space: (1) assistance in deployment or assembly of large spacecraft systems, (2) periodic servicing of free-flying unmanned platforms, and (3) operational support of spacecraft delivery missions needing high performance propulsion stages as well as for science, applications, technology, national security, and commercial missions. We are also studying the broader, longer range aspects of manned presence in space including, for example, potential manned missions beyond the low-earth orbit Space Station.

A significant Space Station planning activity last year, which will continue in 1983, was the preparation of the seven program description documents. MSFC is heavily involved in the preparation of all seven books but has the lead responsibility in preparing the Space Station Systems Definition (Book 5). Approximately one hundred thirty different system/subsystem trades will be conducted by MSFC and other NASA Centers in preparing Book 5. These trades cover a broad spectrum of Space Station issues including program level trades dealing with sizing, mission support capability, initial capability and evolution as well as system and subsystem level design and operational trades. An example of the trades is represented by Figure 2 which reflects typical Space Station sizing options which are being asessed in a parametric fashion in order to bound the program cost and benefits issue.

Along with the study activities being conducted at MSFC, there is also an advanced development program to make long range plans for the transfer of new technology into the Space Station Program. Along this line, MSFC has proposed, along with other centers, to participate in advance development test bed activities in six technical disciplines: Electrical Power; Thermal Control; Data Management; Guidance, Navigation and Control; Propulsion/Fluids; and Mechanisms. MSFC currently has three operating bread boards (test bed) facilities, the Electrical Power System, Space Operations Mechanism, and Guidance Navigation and Control System. The Six Degree of Freedom System (Space Operation Mechanism) shown in Figure 3 is used to test berthing mechanism concepts for the Space Platform, which is directly applicable to the space station. Continued testing is planned in 1983. These test beds will be enhanced and additional test beds initiated to support the Space Station Program.

Concept development studies will be conducted in-house of several space station system configurations. These studies will include numerous programmatic, system and subsystem trades to determine the most cost effective approaches to achieve mission objectives. Different methods of growing the station to meet future needs will also be investigated.

Four contracted Technology Development Missions studies were begun in 1982 for a potential space station. Technology Development Missions are experimental projects utilizing the Space Station to advance space technology. The mission definition areas being studied are Orbit Transfer Vehicle Servicing, Large Space Structures, and Satellite Servicing.

During 1983 MSFC will continue to support the Space Station Task Force in the Agency's planning for a potential space station. Emphasis will be on the early missions that require a manned facility and the systems definition of a space station. Technology and advanced development activities are being focused to support this development.

Geostationary Platform - The communication satellite industry is well established throughout the world. The demand for services is growing rapidly, with a predicted growth rate of 20% or more per year for the next 10-15 years. There is also a trend toward larger and more complex satellites. Examples of this trend and the resulting platform concept that is expected during the next decade are shown on Figure 4. The demand is expected to outstrip capabilities in the near future.

By the late 1990's, additional capability for point-to-point services will be achievable only with the introduction of large-scale frequency reuse, where numerous antenna beams simultaneously utilize the same radio frequency. This can be achieved only by use of very large antennas and on-board switching devices. There is a similar high demand developing for large direct broadcast satellites which will eventually require far more power than can be provided by the anticipated conventional satellites.

To meet the projected demand for large scale frequency reuse, high power and new services, MSFC has been studying Geostationary Platforms which could support the large antennas and provide the needed power. Platforms which could be placed into orbit via a single Shuttle launch were found to be the best choice. The studies considered both the future scenario, in which a number of advanced platforms would be operational world-wide, and also the specific needs for the initial platform. Detailed conceptual designs for the latter were generated, including alternate versions which were primarily for direct broadcast.

Options are also being considered where the Experimental Geostationary Platform development is funded partially by private U.S. investment capital and options where the platform is turned over to industry, at some point in the life of the platform on a revenue-sharing or cost-reimbursement basis.

Large Space Structures (LSS) - MSFC's program to develop the technology to support the future construction in space of large systems continues to make significant strides. Two principal construction methods are currently being explored - deployable (the structure is built on the ground and unfolded or deployed in space) and erectable (the structural members are fabricated on the ground and assembled member-by-member in space).

MSFC is currently investigating four candidate LSS orbital flight experiments for the 1984-85 time period. These experiments, listed in order of their potential launch dates, are SAFE I, EASE, SADE, and SAFE II. The Solar Array Flight Experiment (SAFE I) has been fabricated and is awaiting flight in mid-1984. It consists of a folded surface 105 ft in length by 16 ft wide that is partially filled with solar cells. The system will be deployed out of the Shuttle bay by a coilable and extendable 105 ft mast. This early flight will demonstrate deployment and retraction technologies associated with large

area solar array power systems, and the related dynamic characteristics and limitations in controlling large area flexible structures. These technologies, which are critical to the power needs of future spacecraft and manned space station systems, cannot be demonstrated on the ground due to gravity effects and the extremely light-weight nature of the composite mast/array systems.

Future large solar arrays will require more advanced, efficient solar cells, will need to operate at higher voltages to minimize current transmission weight losses, and will need to be maintained on-orbit. A reflight of SAFE I (called SAFE II) has been proposed by MSFC to address these advanced technologies, and to evaluate the effects of the near-earth plasma on a high operating voltage array.

The Experimental Assembly of Structures in EVA (EASE) and Structures Assembly Demonstration Experiment (SADE) are flight experiments which emphasize platform-like structures. EASE is a very simple early experiment being jointly studied by MIT and MSFC to help understand fundamental EVA-LSS construction techniques. The SADE flight experiment will consider combined techniques (EVA assembly, self-deploying, and deployment assists) for orbital platform construction.

The SADE program and its supporting elements are outlined in Figure 5. The hardware and test data from a previously fabricated Science and Applications Space Platform truss are being used to guide the design of an advanced truss applicable to the SADE flight experiment. Recent experience gained in MSFC's Neutral Buoyancy Facility (NBS) in the evaluation of typical deployable trusses will assist in developing the SADE truss.

Some of the bays or segments of the SADE flight experiment truss will be EVA-assembled, member-by-member. This technique has also been evaluated in MSFC's NBS at shown in Figure 5 and will be further demonstrated and confirmed by the EASE flight experiment proposed for 1984. As shown in Figure 5, the SADE flight, involving a combination of deployment and erection construction methods, embodies and demonstrates many techniques and technologies critical to future LSS orbital construction program needs.

Basic structures and joint/connector designs will be demonstrated; man's capabilities will be assessed; and the Shuttle's ability to support a structure assembly/construction task in orbit will be evaluated.

Tethered Satellite System (TSS) - The TSS, as shown in Figure 6, is a reusable facility that utilizes the Shuttle as a base and allows access to low altitudes by reeling out an instrumented spacecraft on a long ($\sim$100 km) tether from the Shuttle bay. This will provide an important and unique new Shuttle and/or platform-based facility for immediate uses ranging from geological surveys to atmospheric and ionospheric measurements and per-

turbations. Investigations can also be made of electrodynamic and plasma phenomenon using the naturally occurring space plasma. In addition, tether systems might also be used to generate electrical power, launch subsatellites, transfer objects from one orbit to another, provide a partial "g" environment, and for large antennas.

The TSS is a joint endeavor between NASA and the National Space Plan (PSN) of the Italian National Research Council (CNR). A Memorandum of Understanding (MOU) will be established this year between NASA and the Italian Ministry of Scientific Research and Technology (MRST). This MOU will delineate NASA and PSN/CNR responsibilities for the joint development activity. It is planned for the first mission that PSN/CNR have the responsibility to develop the satellite, integrate the satellite science instruments, and to support the overall integration activities as required. NASA is expected to develop the deployer system and overall systems integration. A joint U.S./Italian TSS Science Working Group was established in 1981 to evaluate science mission candidates and accommodation requirements for use of the system. This group will conclude their activities and be disbanded prior to issuance of a joint U.S./Italian Announcement of Opportunity (AO) in 1983.

A thirteen month Advanced Development contract has been awarded to Martin Marietta Aerospace/Denver Division, with an option, pending congressional approval, for a thirty-nine month design and development phase starting January 1984, with a flight in the second quarter of 1987.

ADVANCED TRANSPORTATION SYSTEMS

The technology, planning and analysis efforts at MSFC to define and develop the systems required to meet the Nation's future propulsion and space transportation needs continue. Among the systems under study are those that increase the utility of the STS to deliver and retrieve payloads, orbit transfer vehicles, unmanned launch vehicles derived from the Shuttle, and improvements to the STS such as methods to increase the Shuttle's cargo carrying volume.

Transfer Orbit Stage (TOS) - The current stable of upper stages for the Space Shuttle covers a wide range of capabilities from the modest PAM-D to the Centaur. On the high performance end of the spectrum, IUS and Centaur, meet or exceed most requirements; however, these systems represent costly solutions. The commercial communications satellite industry requirements for space transportation has typically included only a perigee burn. These satellites have integral propulsion to perform both the second or apogee burn and station keeping propulsion maneuvers over the lifetime of the spacecraft. PAM-D and PAM-A were developed commercially to meet the needs of this satellite industry.

In the late 1980's a new class of commercial communications satellite is expected to emerge that will require increased performance. There exists a cost/performance gap between the PAM class upper stages and the IUS/Centaur stages. Arianne IV is projected to provide the perigee propulsion for payloads in this performance range in the mid 1990's. NASA was preparing to fund the definition of a stage in this performance class: 6,000 to 13,000 pounds to a geostationary transfer orbit. This stage, named the Transfer Orbit Stage or TOS, is based upon the use of the already developed IUS first stage solid rocket motor.

Prior to the release of the NASA RFP for Phase B studies on the TOS, an offer to commercially develop the stage was received and negotiations are currently underway to reach an agreement to proceed with the commercial development of TOS within the next several months.

Teleoperator Maneuvering System (TMS) - Now that the Shuttle is operational, there appears to be a number of unique benefits offered by the use of a "mini" or "harbor" tug (TMS) operating in concert with the Shuttle orbiter, possibly as early as 1987-88. To date, the studies conducted by MSFC have shown that the effective "sphere of influence" of the Shuttle may be substantially and cost effectively increased with the use of a TMS capable of delivering and retrieving payloads to and from the Shuttle's standard orbit (160 n. miles altitude) out to and altitudes up to 2,000 miles. For high-energy missions up to and including geostationary orbit, a TMS propulsion stage would augment the Transfer Orbit Stage (TOS) system in providing an effective low-cost second stage system for delivering intermediate sized payloads to geosynchronous orbit. Similarly, a TMS with an attached payload delivered to GEO by a Centaur upper stage could provide an effective delivery and on-orbit support capability for a larger class of payloads operating as an unmanned remotely controlled free-flying system. The TMS could also provide a wide range of remote satellite services beyond basic placement and retrieval functions, including payload viewing, payload repositioning/ phase changes, sub-satellite science support, satellite servicing using manned telepresence to accomplish major module or element exchange, satellite refueling, large space structues assembly support, and logistics support to low-earth orbit spacecraft or platforms. The TMS could provide a wide range of "work-horse" tasks in support of the Space Station and its associated unmanned free-flying platforms/payloads, as shown in Figure 7.

The TMS would be developed in a modular way which permits adding "mission kit" capabilities as they are needed; or, conversely, readily removing them when not needed for a specific mission. Early TMS missions would involve payload placement, retrieval, viewing, or the use of the TMS propulsion module for spacecraft maneuvering or upper stage performance augmentation. Later missions would involve servicing operations, and the possible capture, controlled re-entry, or reboost of space debris/mal-

functioning satellites. Mission kits, including radar, television systems, docking devices, and specialized manipulator arms would all eventually become part of the TMS inventory.

MSFC is updating its assessment of the TMS requirements and benefits analysis this year. We plan to pursue further definition studies next year as part of the planning cycle for the consideration of the TMS as a post-FY84 new start.

Orbit Transfer Vehicles - As the level of activity at Geosynchronous Orbit (GEO) increases toward the beginning of the 1990's, it would be desirable to provide a versatile, reusable Shuttle upper stage with greater payload capabilty, thereby extending Shuttle type reusability to GEO. The class of reusable upper stage for such advanced missions is referred to as "Orbit Transfer Vehicles (OTV)." Configurations, such as the one illustrated in Figure 8 are being studied. This OTV would provide for reusability and high performance levels and would be designed with an aeroassisted return from high orbit taking advantage of aerobraking techniques upon OTV return to low-earth orbit. This would provide significantly increased GEO payload capability in the reusable OTV mode. Reusability, afforded by aeroassist, can permit the OTV and associated payloads to become space-based and thereby enhance the economics of STS beyond low-earth orbits. A full capability aeroassist OTV, later combined with a crew module, could then accommodate manned sortie missions to GEO or other high energy orbits. Concept studies and technology efforts in propulsion systems, cryogenic systems, and aeroassist provisions are being pursued to build an adequate foundation for reusable OTV development.

Shuttle-Derived Vehicles (SDV) - The term "Shuttle-Derived Vehicles" is used as a generic term to include unmanned launch vehicles derived from the Shuttle by combining the propulsion elements in different arrangements; or, possible major block changes/improvements, such as future replacement of solid propellant boosters with reusable liquid rocket boosters. Our work during the past year has been mainly in the former category.

We have examined one class of vehicles made up largely of solid rocket booster components that could be used as unmanned launchers for Titan-Shuttle class payloads (called "SRB-X" vehicles). If the need should arise for continued use of unmanned launch vehicles in this class, use of Shuttle components already developed and in production would be a prime candidate to meet that need.

When the need develops in the future for payloads that are bigger or heavier than the Shuttle Orbiter can accommodate, Shuttle propulsion elements can be configured to meet that need with moderate leadtime and cost. The two versions of "Shuttle-Derived Cargo Vehicles (SDCV)" that are currently being investigated are shown in Figures 9 and 10. Studies have continued to define the configuration and capabilities of the "side-mount" cargo vehicle, depicted in Figure 9, in which the main engines, avionics and other high-cost components are returned to earth in a recoverable module. Early work on the "in-line" SDCV, Figure 10, assumed the main engine(s) would be expended with the propellant tank. However, recent work has examined a promising approach for recovery of engines and avionics in this configuration also. This would, of course, provide a lower cost launch for future large payloads.

Advanced Liquid Propulsion Technology - From past experience in technology and advanced development funding, it has generally been true that resources used on rocket engines and propulsion systems provide explicit cost and performance benefits. More often than not these benefits are enabling in both a programmatic (engines are generally the longest lead items) and a capability sense.

The current emphasis in engine activities should be continued and some additional emphasis and effort should be initiated. For example, a goal might be to increase the current effort by 50-100% over a 2-year period.

Aft Cargo Carrier - The Aft Cargo Carrier (ACC) would be essentially another payload bay for the Shuttle, mounted at the rear of the external tank as shown in Figure 11. The ACC would provide a usable volume of approximately 10,000 cubic feet which is roughly equal to the orbiter payload bay. Design features such as thermal protection, acoustic attenuation, electrical power and data will provide essential payload environments and services, just as provided in the Orbiter. The ACC shroud is jettisoned shortly after SRB separation, and the Orbiter/ET/ACC continue via direct ascent to orbit where the Orbit Maneuvering System (OMS) is used to circularize. The ACC would provide twice the existing Shuttle volume on each launch used, within the present payload weight limit. Figure 12 shows some of the potential applications of the ACC.

MATERIALS EXPERIMENT ASSEMBLY (MEA)

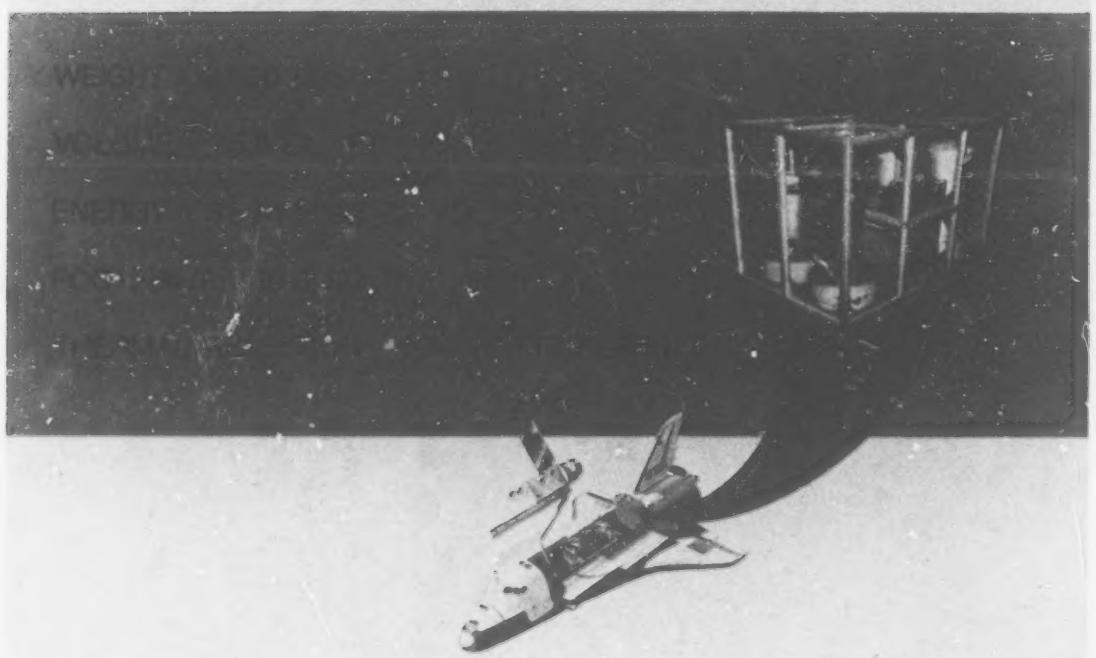


FIGURE 38

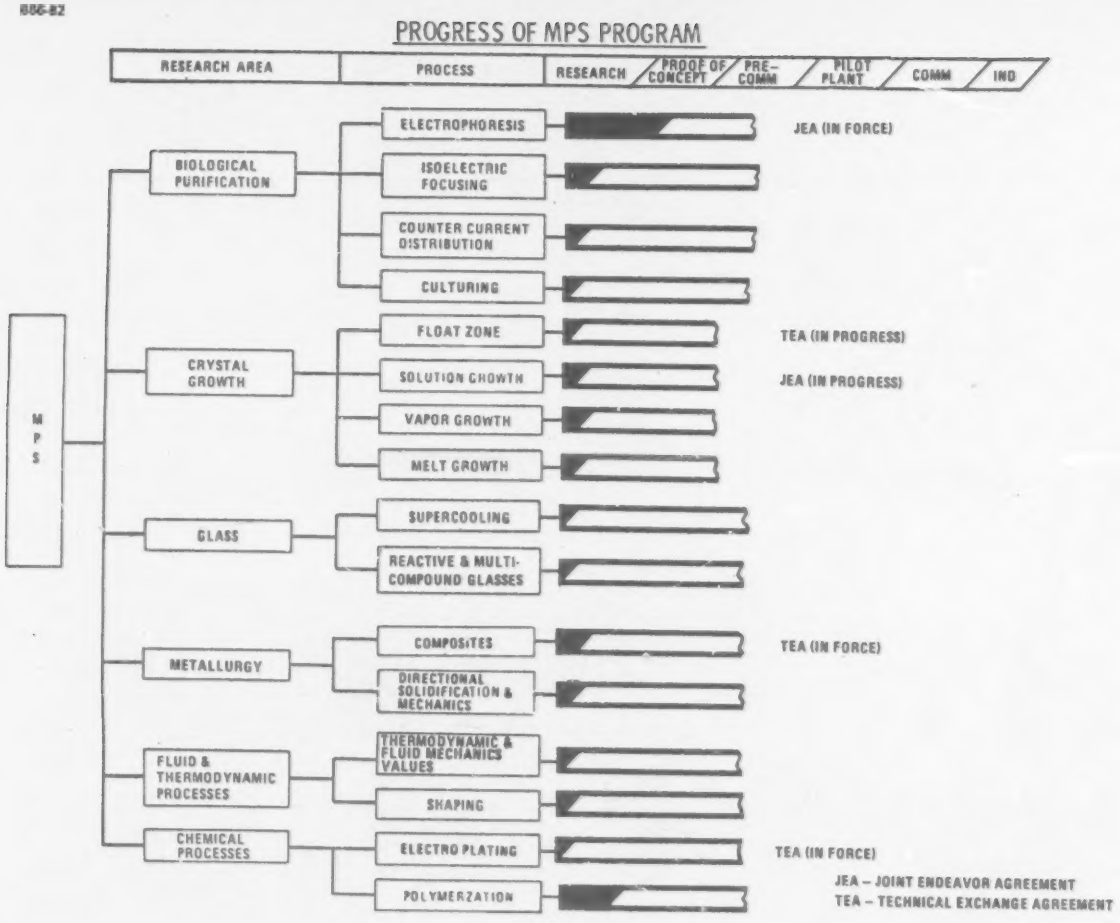

PROGRESS OF MPS PROGRAM
RESEARCH AREA
PROCESS
RESEARCH
PROOF OF CONCEPT
PRE-COMM
PILOT PLANT
COMM
IND
MPS
BIOLOGICAL PURIFICATION
ELECTROPHORESIS
ISOELECTRIC FOCUSING
COUNTER CURRENT DISTRIBUTION
CULTURING
JEA (IN FORCE)
CRYSTAL GROWTH
FLOAT ZONE
SOLUTION GROWTH
VAPOR GROWTH
MELT GROWTH
TEA (IN PROGRESS)
JEA (IN PROGRESS)
GLASS
SUPERCOOLING
REACTIVE & MULTI-COMPOUND GLASSES
METALLURGY
COMPOSITES
DIRECTIONAL SOLIDIFICATION & MECHANICS
TEA (IN FORCE)
FLUID & THERMODYNAMIC PROCESSES
THERMODYNAMIC & FLUID MECHANICS VALUES
SHAPING
CHEMICAL PROCESSES
ELECTRO PLATING
POLYMERZATION
TEA (IN FORCE)
JEA – JOINT ENDEAVOR AGREEMENT
TEA – TECHNICAL EXCHANGE AGREEMENT

FIGURE 39

SCIENCE AND APPLICATIONS PAYLOADS

Future Science and Applications payloads remain an important area of activity at MSFC. Significant strides have been made in the planning and technology work for two very important science missions, the Advanced X-Ray Astrophysics Facility, and Gravity Probe-B. Payloads that would initially be flown aboard the Space Shuttle and evolve to Space Station/Platform facilities also comprise an important area of study.

Advanced X-Ray Astrophysics Facility (AXAF) - As illustrated in Figure 13, the progress of X-ray astronomy during its brief 20 years of existence has been remarkable. Beginning with the discovery of the first extrasolar source using instruments aboard a small exploratory rocket in 1962, we have progressed to the first image-forming X-ray telescope aboard HEAO-2. During the two years of its operational lifetime, which ended in 1981, thousands of X-ray sources were observed by HEAO-2 - advancing X-ray astronomy to a position comparable in importance to that of astronomy in other wavelength regions. This has led the scientific community to urgently call for a long-lived X-ray observatory that would complement the Space Telescope and the Very Large Array.

Utilizing the same basic principles as were tested and proven on HEAO-2, the improvements in the technology of polishing and figuring mirrors and the capabilities provided by the Space Shuttle, it is now practical to develop a national X-ray observatory - AXAF. Compared with HEAO-2, AXAF will offer a factor of ten improvement in angular resolution, broader energy coverage, 100 times the sensitivity, and will operate for at least ten years.

Scientific investigations with AXAF will encompass almost the entire range of celestial objects. Detailed studies of stars, supernova remnants, galaxies, and compact objects (e.g., neutron stars and black holes in binary systems) will greatly expand our understanding of the Universe. The great sensitivity of AXAF will permit us to investigate galaxies and clusters out to such far distances that the effects of evolution of the early Universe should be seen. The mysteries of the central engines that power quasars and active galaxies will be probed by the high resolution AXAF.

The great promise of AXAF, only briefly outlined above, has led the National Academy of Sciences to list the development of AXAF as the highest priority for astronomy in the 1980's.

During the past year, conceptual studies have resulted in an improved understanding of the alternative configurations and design approaches available for meeting AXAF scientific goals. It has been demonstrated conceptually, for instance, that a potential exists for high inheritance of mature design approaches.

An Announcement of Opportunity for the scientific instruments is scheduled to be released in March, and planning for the initiation of systems definition contracts later this year is essentially complete.

The technology of X-ray optics is being advanced to a state of full readiness, through two on-going programs at Perkin-Elmer and ITEK. Scaled-down versions of the AXAF flight type mirrors are being prepared for X-ray testing at MSFC later this year.

Gravity Probe-B (GP-B) - Einstein's General Theory of Relativity currently forms the basis for our understanding of the Universe at large. Recently, it has attracted new interest through the possible detection of a gravitational lens and black holes, and the study of other exotic cosmic objects. The theory, however, is difficult to test experimentally. The objective of the GP-B mission is to accomplish an experiment in which a gyroscope in motion about the earth undergoes two relativistic precessions with respect to the fixed stars. The larger component (known as the geodetic effect) is 6.9 arcsec/year, and the smaller component (known as the motional or gravimagnetic effect) is only 0.05 arcsec/year. Neither the magnitude nor the existence of the gravimagnetic effect, which is the gravitational analog of magnetism, has ever been experimentally demonstrated.

The GP-B observatory is shown in Figure 14. The heart of the experiment is four ultra-stable quartz gyroscopes. The gyroscopes are contained in a quartz block to which an all quartz telescope is attached. This entire assembly is enclosed in a superconducting magnetic shield which in-turn is contained inside a liquid helium dewar. The dewar is the main body of the spacecraft, and when the other necessary subsystems are added to it, the result is the GP-B spacecraft/ experiment assembly.

The MSFC in-house Phase B study, which began in November 1980, has been completed. The Phase B baseline configuration and project planning for Phase C/D have been reviewed and endorsed by Center Management, the Gravitational Physics Committee of the National Academy of Science, and a Non-Advocate Review Team. An aggressive advanced technology program on selected components of the GP-B is in progress. Project planning for proceeding into the flight development phase is currently under review by NASA Headquarters.

Evolutionary Science and Applications Payloads - The Space Station/Platform offers important potential benefits for Science and Applications Payloads. The utility of man in an orbiting scientific laboratory has been demonstrated by Skylab. A Space Station could serve as an operations base for the assembly of large astronomical or other energy collecting/imaging systems. Numerous studies have demonstrated both the economic and operations benefits of placing payloads aboard platforms in space. We continue the in-depth study of candidate payloads that would

first be flown aboard the Shuttle and evolve to facilities aboard a Space Station/Platform.

During the 50 years that have passed since the birth of Radio Astronomy, a tremendous variety of cosmic phenomena have been revealed. From the studies of planets in our solar system to the discovery by radio observations of such exotic objects as quasars and pulsars, Radio Astronomy has been indispensible to our probing of the Universe. By using an intercontinental network of radio telescopes as an interferometer system, astronomers now examine the details of distant celestial objects with a resolution a thousand times finer than the best optical telescopes. Nevertheless, ground-based Very Long Baseline Interferometers (VLBI) networks have limitations which can be largely overcome by placing one or more of the antenna/ receivers in space and making simultaneous measurements in conjunction with ground-based radio telescopes. For example, an orbiting VLBI would give us improved angular resolution, improved coverage of the celestial sphere, more accurate radio images and more rapid coverage of time-varying sources.

We have continued to work with the scientific community and other NASA centers to define an orbiting VLBI program that would begin with a Shuttle experiment, as illustrated in Figure 15, and evolve to a Space Platform/Space Station facility.

The Solar Terrestrial Observatory (STO) is a comprehensive combination of instruments to examine the energy transfer mechanisms from the sun through the earth's magnetosphere into the earth's atmosphere. The presence of man to observe, correlate, recognize and anticipate significant events will be invaluable. Also since the STO uses instruments which are developed for the Spacelab Program, these instruments already take into account the presence of man, and in most cases, are built to provide for optimum manned interaction. Whereas the multiple observational and remote sensing capabilities provided by the STO offer a tremendous research potential, the addition of the active experiments adds the critical element to consider the STO as a "research station in space" that may benefit greatly from the capabilities offered by the Manned Space Station.

The Pinhole/Occulter Facility (POF), Figure 16, is a novel instrumentation concept that will provide for a major improvement in sensitivity and resolution for both X-ray and coronagraphic observations of the nonthermal phenomena central to understanding solar activity. In essence, the Pinhole/Occulter Facility consists of a large boom erected from the Shuttle bay or other platform; the boom serves the function of separating an X-ray mask/occulting disk from the detectors and coronagraph optics. The long baseline permits very high angular resolution and sensitivity. Preliminary feasiblity studies have verified the engineering feasibility of this concept.

Advanced Optical Systems - The Space Telescope is probably the finest optical instrument ever built. Its resolution is 10 times better than the best ground-based telescope. However, future astronomical investiqations can already project the need for angular resolution approaching a milliarcsecond. Telescopes with such a resolving capability would require primary mirror diameters of 15 to 30 m diameter; certainly too large to be transported by the Space Shuttle as an operational entity. These systems must be assembled from individual segments on orbit.

In recognition of this future need for telescopes with high angular resolution and very large collecting areas, several concepts for advanced space telescopes are being studied at MSFC. Two major systems are a Coherent Optical System of Modular Imaging Collectors (COSMIC) (an optical interferometer) and an off-axis Gregorian Telescope with rectangular aperture (Slot or Strip telescope). Although these systems differ from each other in their optical and structural configurations, they have common technology requirements in such areas as structural and thermal stability and dimensional control. Advanced technology studies now under way for these systems address certain subsystem problems such as mirror segment shape and edge-to-edge alignment measurements. In order to establish the feasibility of these concepts, other technology drivers must still be identified in conjunction with overall systems studies. Because we cannot select a specific concept for an advanced optical system without considerable trade studies, it is imperative that the technology studies be directed toward a generic type of technology development. This would not only provide sufficient depth to conduct general system optimization studies, but would also offer a basis to develop solutions to specific barriers, such as structural tolerance control, pointing, and stability achievement.

Doppler Lidar Wind Profiler - The Doppler Lidar Wind Profiler is a LIDAR (Light Intensification, Detection and Ranging) system, operating in low-earth orbit, to remotely measure global atmospheric winds. The free-flying satellite concept, referred to as WINDSAT, is shown in Figure 17. Knowledge of global atmospheric wind direction and velocity would be of immense utility to both the operational and research activities of meteorological organizations. Ground-based technology efforts are currently being conducted by NASA, NOAA, and the Air Force would lead toward the development of a future space-borne system.

An airborne laboratory LIDAR system, developed at MSFC for research purposes, has recently completed a highly successful measurement season. Important research data in a variety of different atmospheric conditions have been obtained via NASA's CV990 aircraft.

COMMERCIAL MATERIALS PROCESSING IN SPACE

During 1982, significant progress was made in NASA's joint program with U.S. industry to accelerate the commercialization of Materials Processing in Space (MPS). Specifically, this joint program addresses basic and applied research to better understand the pervasive role of gravity in materials processing; to develop and demonstrate enhanced control of materials processes in a low-gravity environment (MPLG); and to foster commercial applications of MPLG technology with regard to its usefulness in the private sector where economic benefits may result.

Several joint NASA/industry commercial projects are in progress involving areas of scientific research in metallurgy, crystal growth, and biological separations. These joint projects involve varying degrees of commitment by the parties.

The first Joint Endeavor Agreement (JEA) signed with McDonnell Douglas Astronautics Company (MDAC) is progressing on schedule. The first flight of the Continuous Flow Electrophoresis System (CFES), built by McDonnell Douglas with their own funds, was carried out last June on the Shuttle's fourth flight (STS-4). The CFES performed almost flawlessly. Three additional flights of the CFES are scheduled in 1983 to qualify it to produce pharmaceutical materials suitable for clinical tests. A second project oriented JEA between NASA and Microgravity Research Associates (MRA), Coral Gables, Florida, to develop and demonstrate an advanced crystal growth process for commercial purposes is in the final stages of approval.

Three Technical Exchange Agreements (TEA's) are in varying stages of progress. The TEA's with Deere and Company and INCO Research and Development Center are proceeding well. A number of low-g experiments and tests aboard NASA aircraft and in the drop tube at MSFC have contributed to a better understanding of gravity-driven phenomena in the formation of cast iron and mass transport phenomena in electrodeposition. Also, collaborative research with DuPont on immiscible materials using MSFC's drop tube in under way. Another TEA involving joint research with semiconductor materials is in the final stages of approval. Several other firms are seriously considering TEA's for high technology materials development. Interest remains high throughout the industrial community as to the importance and need of a continuing joint NASA/industry commercial oriented program.

This brief review of MSFC's advanced planning activities is representative of the Center's interest and commitment to the future. The commitment of the appropriate technical and management skills to the careful planning of advanced programs illustrates the importance the Center continues to attach to the future Space Program.

STATEMENT

OF

MR. JOHN W. THOMAS
MANAGER, SPACELAB PROGRAM

MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and Members of the Subcommittee:

Spacelab is an international cooperative program between NASA and the European Space Agency (ESA) that is being developed as a key element of the Space Transportation System. Designed as a versatile modular laboratory to be carried in the Shuttle Orbiter bay, Spacelab provides manned modules with shirt-sleeve environment and unpressurized instrument pallets suitable for conducting research and applications activities on Shuttle sortie missions. Intended to complement the economics of the reusability of the Space Shuttle, Spacelab also is reusable and has a minimum design life of ten years and can be flown for at least 50 missions. Figure 1 depicts the modular Spacelab major hardware and software components along with the prime and co-contractors responsible for the components. Figure 2 shows the approximate contribution by the participating European Space Agency nations.

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Under the NASA/ESA Memorandum of Understanding, NASA is responsible for overall program planning and management, development of selected hardware and software, follow-on procurement, and operations. ESA is responsible for design, development and delivery to NASA of engineering and flight models of the module, pallets, their associated support equipment, an Instrument Pointing System,(IPS), limited post-development engineering support, and production of NASA-procured Spacelab hardware. In return, ESA will share in the payload for the first mission and NASA will procure additional Spacelabs as required from ESA.

In preceding testimony to the subcommittee, it was reported that the Engineering Model (EM) and Mechanical Ground Support Equipment (MGSE) had been received in the United States and were being prepared for verification testing; that the initial set of flight hardware and electrical GSE had been received at the KSC in good condition; that NASA hardware and software developments were proceeding on schedule; and that NASA had successfully flown an EM version of the SL pallet with added available subsystems, called the Orbital Flight Test (OFT) Pallet System, on the second Shuttle flight carrying a substantial payload termed OSTA-1.

Review of 1982 Progress

This past year, as was forecast during the Subcommittee's last visit to Marshall, has been very rewarding and filled with substantial progress.

A second OFT Pallet System carrying another significant complement of scientific experiments, OSS-1, was successfully flown on STS-3, the third Shuttle flight. The remaining ESA provided hardware, the igloo and pallets flight hardware and GSE, was received in the U.S. and has been partially assembled at the KSC awaiting the payload for the mission designated SL-2.

The development of NASA hardware and software elements, including Spacelab Transfer Tunnel, Experiment Computer Software, Closed Circuit Television System, high optical quality window and the Verification Flight Instrumentation (VFI) has been completed and flight items are now at KSC.

Progress toward the first flight of Spacelab, SL-1, has been particulary significant. The ESA produced module and pallet have been checked out, the NASA provided hardware and software along with the scientific experiments have been integrated, and the combination is now being tested as an integrated payload. These various elements are depicted in Figure 3. The IPS, being developed in Europe to provide experimenters pointing capability in the order of two arc seconds - much better than can be provided by the Orbiter and Spacelab alone, is on schedule, even though redesign became necessary because the input loads from the Orbiter increased. Its first use is planned for SL-2 and, as forecast, will be available in sufficient time for integration.

The Follow-on Procurement (FOP) facet of the program has shown much progress. A large majority of the individual hardware elements have been manufactured and are now being assembled at the European prime contractor's facility in Bremen, Germany. These processes have progressed essentially trouble-free, and the final tests are expected to be completed in the same manner.

A particularly noteworthy milestone was accomplished in January of this year with the culmination of the Spacelab Design Certification Review. The review, acclaimed to represent one of the most thorough ever conducted by NASA, resulted in the certification that the design of Spacelab met all its requirements, was appropriately verified, and is safe and flightworthy.

Future Outlook

The upcoming year will be as densely populated with significant milestones as was 1982. It will again demand extraordinary individual and organizational effort and dedication.

The preparations leading to the planned launch of SL-1 in late September will involve many more tests, assessments of flight readiness, installation into the Orbiter, and finally planning for technical and managerial support for the flight. During the actual flight, progress will be monitored primarily from the MSFC Huntsville Operations Support Center.

Concurrent with preparation and flight of SL-1, engineering, planning, and assembly of flight hardware will be initiated for two additional Spacelab flights, SL-2 and SL-3. Preparation will also be initiated for several lesser missions using singular Spacelab pallets and subsystems.

Having significantly progressed toward the goal of establishing the flight hardware fleet, attention must now be directed toward the operational era. The major goal in this phase of the program is primarily oriented toward economic utilization of Spacelab. The program is actively pursuing means of minimizing the total mission cost and results are optimistically anticipated this year.

Production and integration of the FOP flight hardware under a fixed price arrangement with ESA will continue this year with full expectations of final delivery in 1984.

In summary, the Spacelab continues to progress well and is in accord with current Space Shuttle flight assignments. The European development program is largely complete, and the flight hardware, ground support equipment, and software have been accepted by NASA and reside in the U. S. The agency, with the lead taken by Marshall, has certified that this fleet meets its design requirements, is safe, and is flightworthy.

The first flight unit has now been assembled and is in the process of test and checkout at the Kennedy Space Center with the experiments integrated in racks and onto the pallet. Production of the MSFC-developed hardware and software for Spacelab has paralleled the European activities and has progressed satisfactorily with the Spacelab Transfer Tunnel, Spacelab Window Adapter Assembly, and the Computer Operating Systems having been delivered to Kennedy Space Center for integration with Spacelab 1. Installation of MSFC-produced verification flight instrumentation used to support the verification flight test program for the first two flights is also progressing on schedule. The unprecedented event of the flight of SL-1 representing by far the largest joint international cooperative venture is eagerly anticipated.

SPACELAB
PRIME AND SUB CONTRACTORS

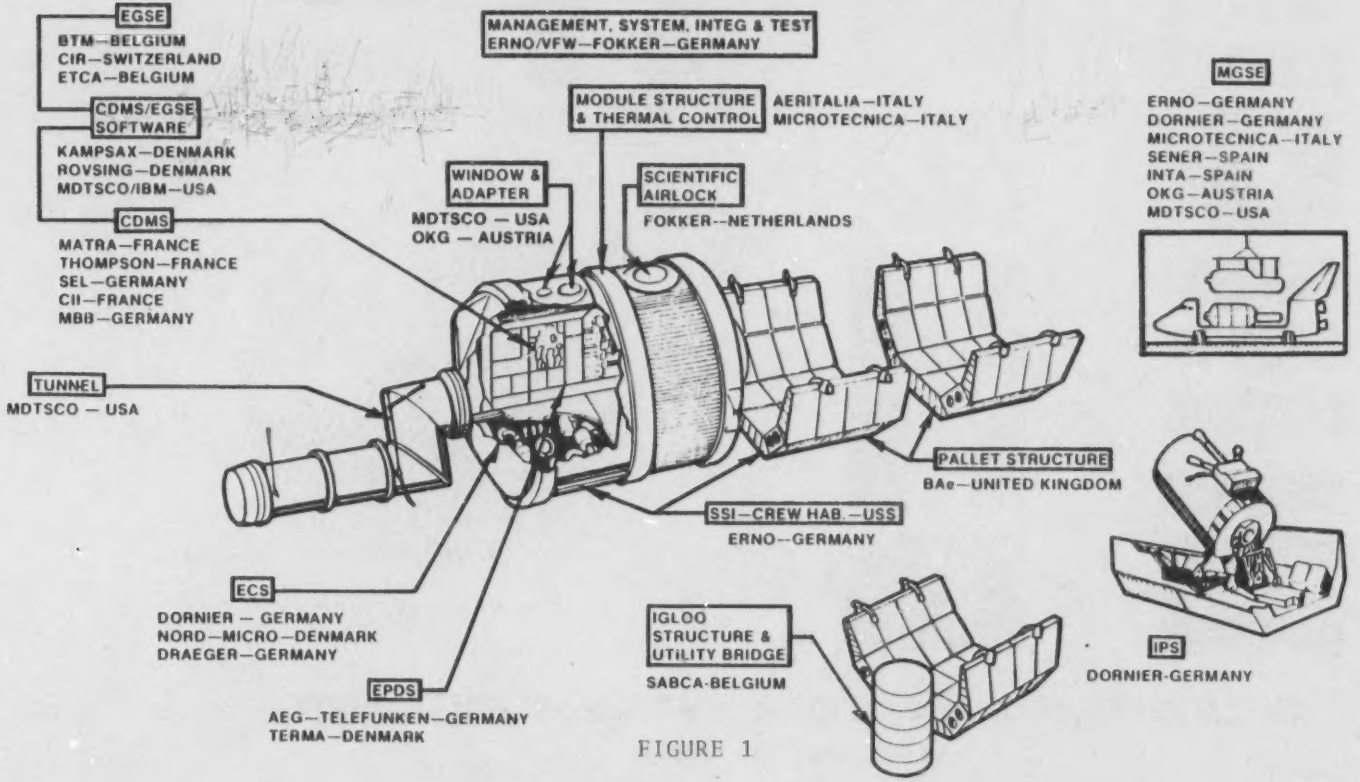


FIGURE 1

STATEMENT

of

MR. JAMES A. DOWNEY III
MANAGER, SPACELAB PAYLOAD PROJECT OFFICE
MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

on

SPACELAB PAYLOAD PROJECTS

Mr. Chairman and Members of the Subcommittee:

This statement provides an overview of Marshall Space Flight Center's (MSFC) Spacelab mission payload assignments. The term mission, as used in this statement, includes all activities associated with the payload, but does not include the basic Space Transportation System (STS) support.

The Marshall Center has responsibility for Spacelab Mission 1, Spacelab Mission 2, and Spacelab Mission 3, as well as certain partial payloads for future Space Shuttle missions. Since the last statement to the Subcommittee, MSFC has been assigned responsibility for the Space Plasma Physics Laboratory, which is now in the definition phase. In addition, responsibility for the major elements of the Materials Processing in Space Program has been assigned to the Spacelab Payload Project Office (SPPO). Managers have been designated within SPPO to manage the implementation of these assignments.

MISSION MANAGEMENT ROLE

The basic function of the mission management team is to represent the payload user community in the utilization of the STS by providing an interface between the payload

cargo requirements, operational capabilities, and safety requirements of the STS. This relieves the users of the need to resolve the complexities of payload-to-Spacelab interface problems allowing them to concentrate on development of their experiments.

The Mission Manager negotiates STS services for the users and assists them in meeting the scientific and applications objectives in the most economical manner. The Mission Manager's responsibilities include all aspects of the mission as illustrated in Figure 1. This includes the budget for integration, interfaces between mission elements, schedules, integration planning, and real-time execution of the mission in conjunction with the Mission Control Center for the STS at the Johnson Space Center.

MISSION ASSIGNMENTS AND STATUS

The Spacelab missions and partial payload missions assigned to MSFC for implementation are discussed below, including a brief description of the status and accomplishments during the past year. The objectives of these missions have not changed since the last statement to the Subcommittee, and are not described in detail in this statement. Changes in launch dates since the last statement to the Subcommittee are specified.

The objectives of Spacelab Mission 1, a joint National Aeronautics and Space Administration (NASA) and European Space Agency (ESA) mission, are basically to test the Spacelab systems and demonstrate the research capability of Spacelab. The current launch date for this mission is September 30, 1983 on STS-9.

Spacelab Mission 1 is a long, pressurized module and pallet configuration as shown in Figure 2. The payload complement consists of NASA and ESA experiments listed by discipline in Figures 3 and 4. The mission activities are on schedule to meet the planned launch date in September 1983. Major accomplishments during the past year include completion of the Level IV physical integration at the Kennedy Space Center (KSC) and final selection of the two payload specialists for flight. The two payload specialists are Dr. Byron K. Lichtenberg from the Massachusetts Institute of Technology and Dr. Ulf Merbold from the Max-Planck Institute, Federal Republic of Germany.

The objectives of Spacelab Mission 2 are essentially the same as Spacelab Mission 1, but will test a different complement of Spacelab hardware. The planned launch date for Spacelab Mission 2 is now March 19, 1985 on

STS-24. The launch date specified in the last statement to the Subcommittee was November 1984.

Spacelab Mission 2 is a pallet only configuration as shown in Figure 5. The payload complement consists of the experiments shown in Figure 6. Experiment and mission equipment design and development activities and payload specialist training are progressing on schedule to meet the planned launch date. Major accomplishments during the year include completion of the critical design review of the software and baselining of the ground integration requirements.

Spacelab Mission 3 is the first "operational" Spacelab mission. The objectives are to conduct scientific, applications, and technology experiments in Earth orbit. The current manifested launch date is September 26, 1984. The launch readiness date was specified as August 1984 in the last statement to the Subcommittee.

The Spacelab Mission 3 configuration consists of a long, pressurized module and a support structure as illustrated in Figure 7. The planned investigations and facilities for the mission are shown in Figure 8. The mission hardware development and analytical integration activities are on schedule to meet the planned launch date. During the past year, the payload specialist selection process was initiated and the integrated payload ground operations review was completed.

The Monodisperse Latex Reactor (MLR) was successfully flown on STS-3 and reflown on STS-4 during the past year, and additional flights are planned on STS-6 and 7. This is a self-contained experiment that is flown in the Orbiter mid-deck stowage locker area. The objectives are to study kinetics of MLR chemical reactions in a low gravity environment and produce monodisperse latex spheres. The MLR hardware is shown in Figure 9.

Three other Orbiter mid-deck materials processing payloads were assigned to MSFC in 1982 with the initial flight planned for early-1984 and the final reflight planned for 1985. Mission activities are in progress for each of these payloads. The objectives of these payloads are to conduct materials processing investigations in the low gravity environment of space. These payloads are: Automatic Directional Solidification Facility, Aggregation of Red Blood Cells, and Isoelectric Focusing experiment.

The OSTA-2 partial payload (Figure 10) is a cooperative NASA/Republic of West Germany mission to conduct materials

processing experiments in Earth orbit. It will be flown on STS-7. The integration readiness review was completed in 1982 and all payload hardware deliveries have been completed on schedule to support the planned launch date.

The OAST-1 partial payload (Figure 11) objectives are basically to conduct solar array and large structures technology investigations in Earth orbit. The planned launch date is June 6, 1984 on STS-14. The launch date as of the last statement to the Subcommittee was April 1984. The hardware and mission activities are on schedule for the planned launch date.

The MEA-1 partial payload (Figure 12) objectives are to conduct materials processing experiments in the low gravity environment of space. The current planned launch date for MEA-1 is March 21, 1984 on STS-12. The specified launch date in the last statement to the Subcommittee was April 1984. The initial design review was completed in 1982 and analytical integration activities are continuing. The MEA-1 is the first of a series of Materials Science Laboratory flights which will refly equipment to do a variety of processing studies.

Since the last statement to the Subcommittee, MSFC has been assigned mission management responsibility for three Astro missions. These missions will be designed to conduct astronomical observations of the stars, galactic nuclei and quasars. At the time of the last statement, MSFC was only responsible for analytical integration support to Goddard Space Flight Center (GSFC). The payload will consist of three ultraviolet telescopes mounted on an instrument pointing system. Mission activities and instrument definition activities are in progress with the initial launch planned for early-1986.

The Space Plasma Physics Laboratory (SPPL) is intended to be the first of a group of dedicated discipline laboratories which will be planned for orderly growth over a series of missions, and designed to minimize de-integration and re-integration between flights. The prime scientific objectives of this series of missions are to study wave-particle interactions, beam-plasma physics, magnetosphere-ionosphere-atmosphere coupling, and the Shuttle electromagnetic and plasma environments. Instruments are currently in the definition phase to support ten candidate investigations over a series of three SPPL missions. Candidate instruments include four upgraded versions of instruments to be flown on Spacelab Missions 1 and 2. The Spacelab configuration anticipated to be required to support the first mission is a single

pallet and igloo. The second mission is currently envisioned to consist of approximately twice the number of instruments as the first mission with the third mission including all candidate instruments currently under definition and consisting of a short module plus three pallet dedicated Spacelab configuration. These missions will be flown in the latter half of this decade.

MATERIALS PROCESSING IN SPACE

The Marshall Center is responsible within NASA for exploring and developing the potential for materials processing in space. The primary objectives of the program are to demonstrate the potential processes, foster technological innovation, isolate and characterize the gravitational effects that occur during the production of common materials on Earth and; thus, identify candidates for processing in space, and promote private sector initiative in applied research and commercialization.

During the past year, the first flight experiment of the continuous flow electrophoretic separator was conducted under an agreement with McDonnell Douglas Astronautics Corporation (MDAC). The experiment was highly successful. This is the first step in the development of a commercial venture between MDAC and Johnson and Johnson to use space for the production of pharmaceutical products.

The SPAR rocket program resulted in several highly successful investigations during the past year. For example, the findings from the analysis of samples of Manganese-Bismuth eutectic directionally solidified in low gravity has shown conclusively that the microstructure is substantially different from those solidified under identical conditions on Earth. This could have substantial implications on the understanding of the process of solidification. In addition, a much better understanding of phase separation in monotectic alloys has emerged from recent SPAR rocket experiments using neutral density model materials.

Two major materials processing experiment systems which will fly on Spacelab Mission 3 are now in the testing phase at MSFC. These systems are the Fluids Experiment System (FES) and the Vapor Crystal Growth System (VCGS). Figures 13 and 14 show the experiment hardware. The objectives of these systems are to provide facilities for conducting investigations of growth of crystals in zero gravity. These systems are on schedule for meeting the planned launch date in late-1984.

FUTURE ACTIVITIES

The planned activities for 1983 include continuation of planning and definition of payload integration requirements for assigned missions; design and development of experiments and mission peculiar equipment; continuation of payload specialist training; providing integration support to KSC; and continuation of the Materials Processing in Space Program activities.

The projected Spacelab Mission 1 activities leading to launch in September 1983 include continuation of the payload specialist training activities, completion of payload integration, launch, real-time support during the mission, and removal and disposition of experiment hardware and data upon mission completion. Significant Spacelab Mission 2 activities will include the process of obtaining Headquarters approval of the experiment complement for flight and starting the Level IV physical integration of the payload at KSC. Planned accomplishments for Spacelab Mission 3 include completion of the integration readiness review and start of Level IV integration.

Plans are to launch the MLR mid-deck experiment on STS-6 and STS-7, and the OSTA-2 mission in 1983. Mission preparation and definition activities will continue on the three Orbiter mid-deck materials processing payloads, the Astro missions, the Space Plasma Physics Laboratory, and the partial payload mission assignments.

The Center will continue the activities now in progress in the Materials Processing in Space Program during 1983.

SPACELAB PROGRAM

EUROPEAN SPACELAB PROGRAM CONTRIBUTORS

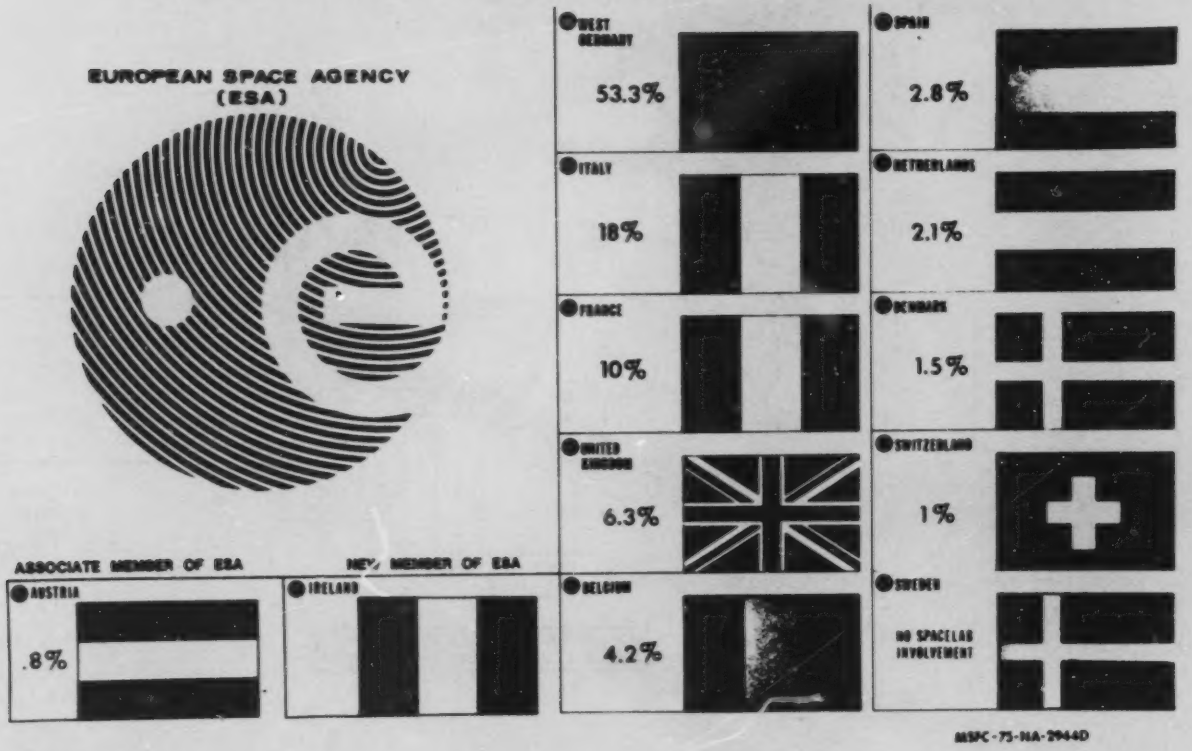
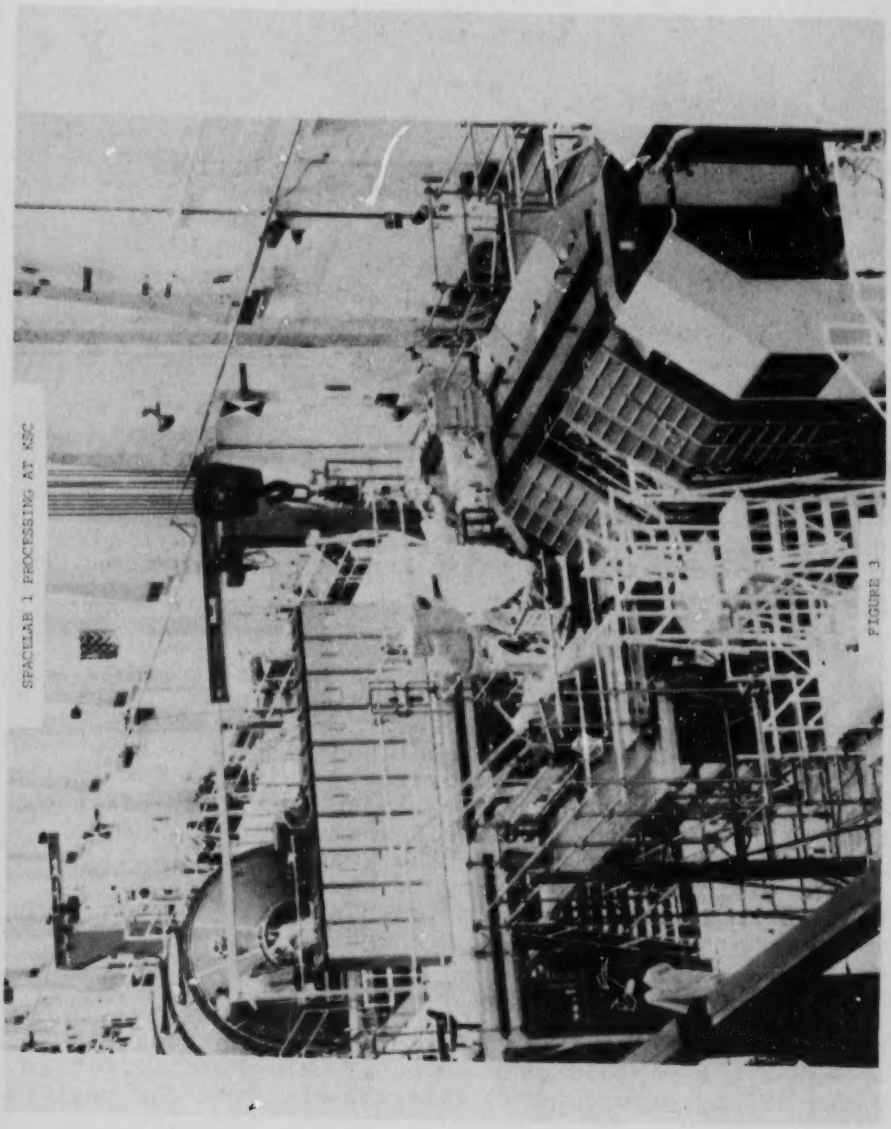


FIGURE 2



SPACELAB 1 PROCESSING AT KSC

FIGURE 3

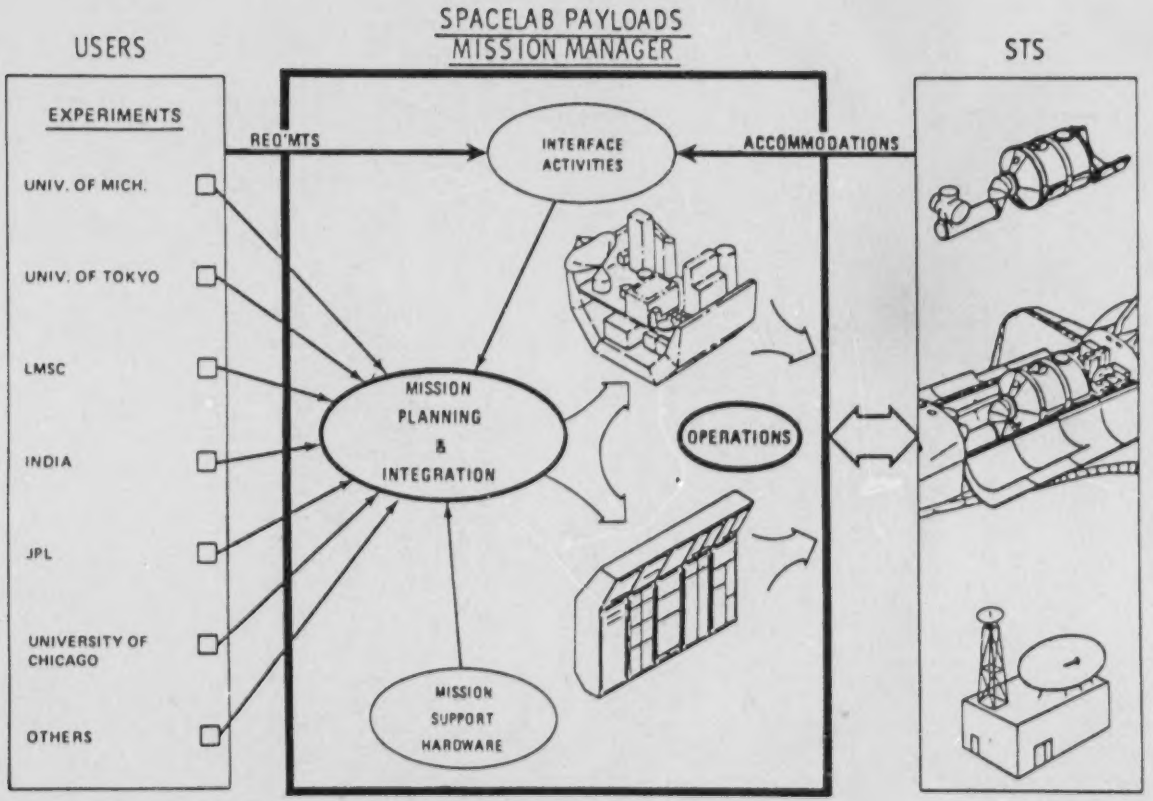

USERS
SPACELAB PAYLOADS
MISSION MANAGER
STS
EXPERIMENTS
REQ'MTS
INTERFACE ACTIVITIES
ACCOMMODATIONS
UNIV. OF MICH.
UNIV. OF TOKYO
LMSC
INDIA
JPL
UNIVERSITY OF CHICAGO
OTHERS
MISSION PLANNING & INTEGRATION
OPERATIONS
MISSION SUPPORT HARDWARE

FIGURE 1

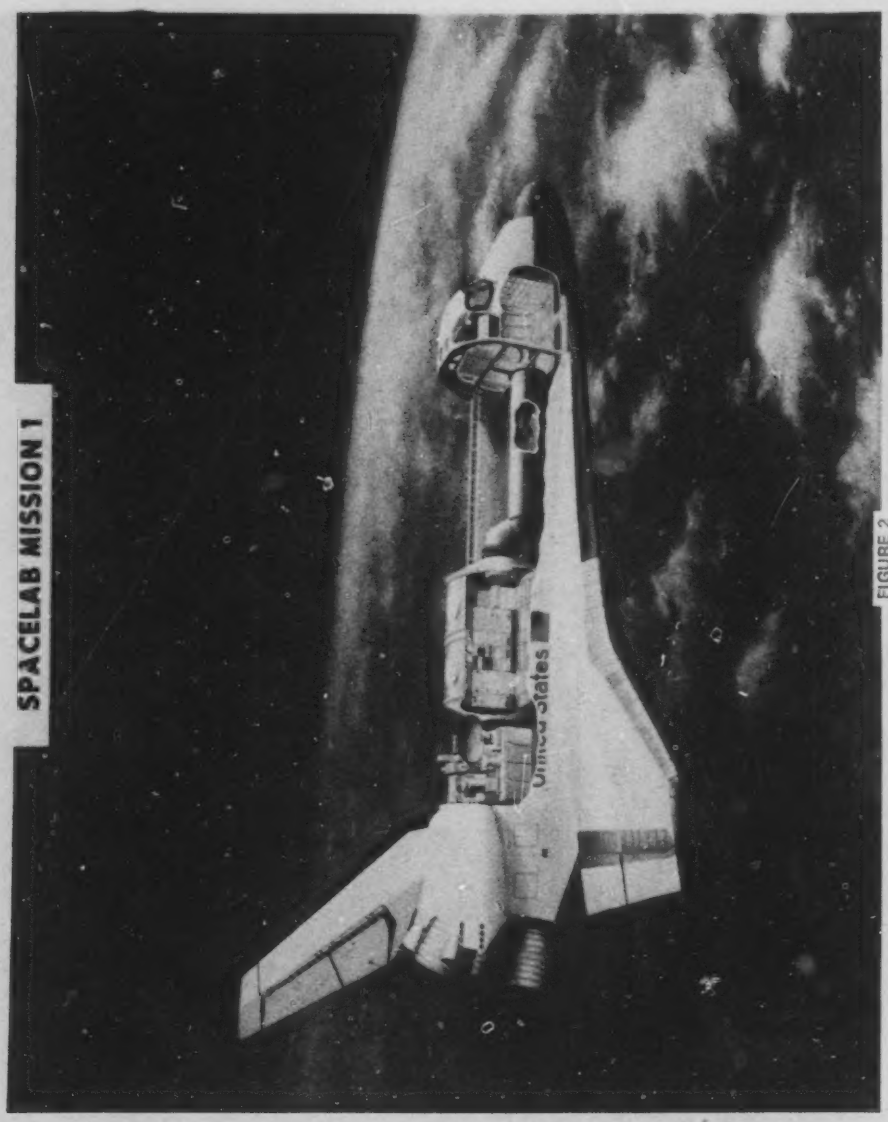


FIGURE 2

SPACELAB 1 NASA INVESTIGATIONS

DISCIPLINE	EXPERIMENT NO.	TITLE	PRINCIPAL INVESTIGATOR/ DEVELOPMENT CENTER
ASTRONOMY AND SOLAR PHYSICS	1NS005	FAR ULTROVIOLET ASTRONOMY USING THE FAUST TELESCOPE	BOWYER–UC–B/MSFC
	1NA008	ACTIVE CAVITY RADIOMETER	WILLSON–JPL/JPL
SPACE PLASMA PHYSICS	1NS002	SPACE EXPERIMENTS WITH PARTICLE ACCELERATORS (SEPAC)	OBAYASHI–JAPAN/MSFC
	1NS003	ATMOSPHERIC EMISSION PHOTOMETRIC IMAGING (AEPI)	MENDE–LOCKHEED/MSFC
ATMOSPHERIC PHYSICS AND EARTH OBSERVATIONS	1NS001	AN IMAGING SPECTROMETRIC OBSERVATORY (ISO)	TORR–UTAH STATE UNIVERSITY/MSFC
LIFE SCIENCES	1NS006	RADIATION ENVIRONMENT MAPPING	BENTON–UNIVERSITY OF SAN FRANCISCO/JSC
	1NS102	VESTIBULAR EXPERIMENTS	YOUNG–MIT/JSC
	1NS104	VESTIBULAR–SPINAL REFLEX MECHANISMS	RESCHKE–JSC/JSC
	1NS105	EFFECTS OF PROLONGED WEIGHTLESSNESS ON THE HUMORAL IMMUNE RESPONSE OF HUMANS	VOSS–UNIVERSITY OF ILL./JSC
	1NS103	THE INFLUENCE OF SPACE FLIGHT ON ERYTHROKINETICS IN MAN	LEACH–JSC/JSC
	1NS007	PRELIMINARY CHARACTERIZATION OF PERSISTING CIRCADIAN RHYTHMS DURING SPACEFLIGHT: NEUROSPORA AS A MODEL SYSTEM	SULZMAN–STATE UNIVERSITY OF NY/JSC
	1NS101	NUTATION OF HELIANTHUS ANNUUS IN A MICROGRAVITY ENVIRONMENT	BROWN–UNIVERSITY OF PA/JSC
MATERIALS SCIENCE	1NT011	TRIBOLOGICAL EXPERIMENTS IN ZERO–GRAVITY	PAN–COLUMBIA UNIVERSITY/MSFC GAUSE & WHITAKER–MSFC/MSFC

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FIGURE 3

SPACELAB 1 ESA INVESTIGATIONS

DISCIPLINE	EXPERIMENT NO.	TITLE	PRINCIPAL INVESTIGATOR/COUNTRY
ASTRONOMY AND SOLAR PHYSICS	1ES022	VERY WIDE FIELD CAMERA	COURTES/FRANCE
	1ES023	SPECTROSCOPY IN X-RAY ASTRONOMY	ANDRESEN/NETHERLANDS
	1ES016	SOLAR SPECTRUM FROM 170-3200 NANOMETERS (1700-32,000 ANGSTROMS)	THUILLER/FRANCE
	1ES021	MEASUREMENT OF THE SOLAR CONSTANT	CROMMELYNCK/BELGIUM
SPACE PLASMA PHYSICS	1ES020	PHENOMENA INDUCED BY CHARGED PARTICLE BEAMS	BEGHIN/FRANCE
	1ES019A	LOW ENERGY ELECTRON FLUX AND ITS REACTION TO ACTIVE EXPERIMENTATION ON SPACELAB	WILHELM/GERMANY
	1ES019B	DC MAGNETIC FIELD VECTOR MEASUREMENT	SCHMIDT/AUSTRIA
	1ES024	ISOTOPIC STACK-MEASUREMENT OF HEAVY COSMIC RAY ISOTOPES	BEAUJEAN/GERMANY
ATOMOSPHERIC PHYSICS AND EARTH OBSERVATIONS	1ES013	GRILLE SPECTROMETER	ACKEMAN/BELGIUM GIRARD/FRANCE
	1ES014	WAVES IN THE OH EMISSIVE LAYER	HERSE/FRANCE
	1ES017	INVESTIGATION ON ATMOSPHERIC H&D THROUGH MEASUREMENT OF THEIR LYMAN-α EMISSION	BERTAUX/FRANCE
	1EA033	METRIC CAMERA EXPERIMENT	REYNOLDS/GERMANY
	1EA034	MICROWAVE REMOTE SENSING EXPERIMENT	DIETERLE/GERMANY

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FIGURE 4

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SPACELAB 1 ESA INVESTIGATIONS (CONT'D)

DISCIPLINE	EXPERIMENT NO.	TITLE	PRINCIPAL INVESTIGATOR/ DEVELOPMENT CENTER
LIFE SCIENCES	1ES026/32	MEASUREMENT OF CENTRAL VENOUS PRESSURE AND DETERMINATION OF HORMONES IN BLOOD SERUM DURING WEIGHTLESSNESS	KIRSCH/GERMANY
	1ES201	EFFECTS OF RECTILINEAR ACCELERATIONS, OPTOKINETIC, AND CALORIC STIMULATIONS IN SPACE	VON BAUMGARTEN/GERMANY
	1ES025	MASS DISCRIMINATION DURING WEIGHTLESSNESS	ROSS/UNITED KINGDOM
	1ES028	THREE-DIMENSIONAL BALLISTOCARDIOGRAPHY IN WEIGHTLESSNESS	SCANO/ITALY
	1ES030	PERSONAL MINIATURE ELECTROPHYSIOLOGICAL TAPE RECORDER	GREEN/UNITED KINGDOM
	1ES031	EFFECT OF WEIGHTLESSNESS ON LYMPHOCYTE PROLIFERATION	COGOLI/SWITZERLAND
MATERIALS SCIENCE	1ES300	MATERAILS SCIENCE DOUBLE RACK FACILITY (33 EXPERIMENTS)	HUTH/FRANCE MALMEJAC/FRANCE NAPOLITANO/ITALY
	1ES322/333	CRYSTAL GROWTH FROM SOLUTION UNDER MICROGRAVITY CONDITIONS	NIELSEN/DENMARK AUTHIER/FRANCE
	1ES338	CRYSTAL GROWTH OF MERCURY IODIDE BY PHYSICAL VAPOR TRANSPORT	BELONET/FRANCE

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FIGURE 4 (CONT'D)

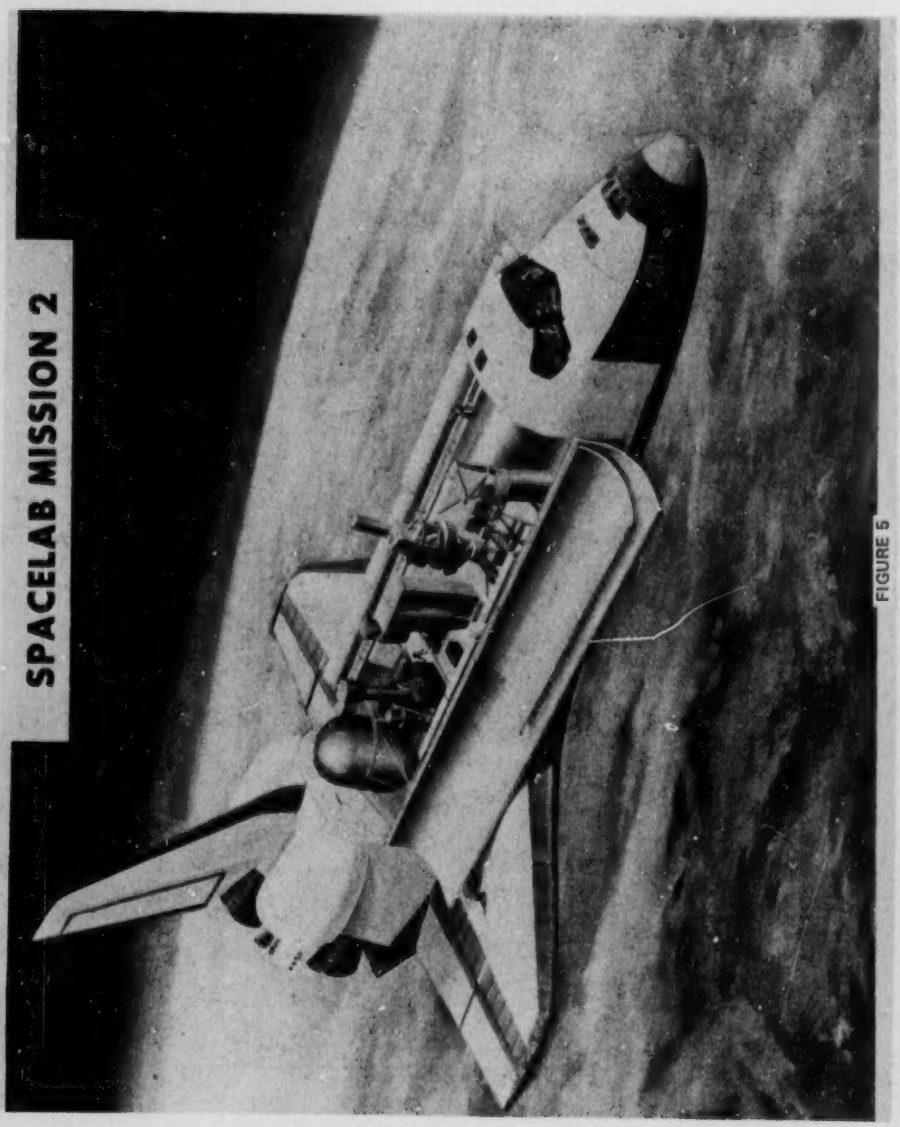

FIGURE 5

SPACELAB 2 INVESTIGATIONS

DISCIPLINE	EXPERIMENT NO.	TITLE	PRINCIPAL INVESTIGATOR/ DEVELOPMENT CENTER
LIFE SCIENCES	1	VITAMIN D METABOLITES AND BONE DEMINERALIZATION	SCHNOES–UNIV. OF WIS./JSC
	2	INTERACTION OF OXYGEN AND GRAVITY INFLUENCED LIGNIFICATION	COWLES–UNIV. OF HOUSTON/ARC
PLASMA PHYSICS	3	EJECTABLE PLASMA DIAGNOSTIC PACKAGE	SHAWHAN–UNIV. OF IOWA/MSFC
	4	PLASMA DEPLETION EXPERIMENTS FOR IONOSPHERIC & RADIO ASTRONOMICAL STUDIES	MENDILLO–BOSTON UNIV./MSFC BERNARDT/LOS ALAMOS NATIONAL LABORATORY
	14	VEHICLE CHARGING AND POTENTIAL	BANKS–STANFORD
ASTRONOMY	5	SMALL HELIUM–COOLED IR TELESCOPE	FAZIO–SMITHSONIAN/MSFC
HIGH ENERGY PHYSICS	6	ELEMENTAL COMPOSITION AND ENERGY SPECTRA OF COSMIC RAY NUCLEI	MEYER & MULLER–UNIV. OF CHICAGO/MSFC
	7	HARD X–RAY IMAGING OF CLUSTERS OF GALAXIES AND OTHER EXTENDED X–RAY SOURCES	WILLMORE–UNIV. OF BIRMINGHAM/ UNITED KINGDOM
SOLAR PHYSICS	8	SOLAR MAGNETIC AND VELOCITY FIELD MEASUREMENT SYSTEM	TITLE–LOCKHEED/MSFC
	9	SOLAR CORONA HELIUM ABUNDANCE SPACELAB EXPERIMENT	GABRIEL–APPLETION LAB/UNITED KINGDOM CULHANE–UNIV. COLLEGE/UNITED KINGDOM
	10	SOLAR UV HIGH RESOLUTION TELESCOPE AND SPECTROGRAPH	BRUECKNER–NRL/MSFC
ATMOSPHERIC PHYSICS	11	SOLAR UV SPECTRAL IRRADIANCE MONITOR	BRUECKNER–NRL/MSFC
TECHNOLOGY	13	PROPERTIES OF SUPERFLUID HELIUM IN ZERO–G	MASON–JPL/JPL

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FIGURE 6

SPACELAB MISSION 3

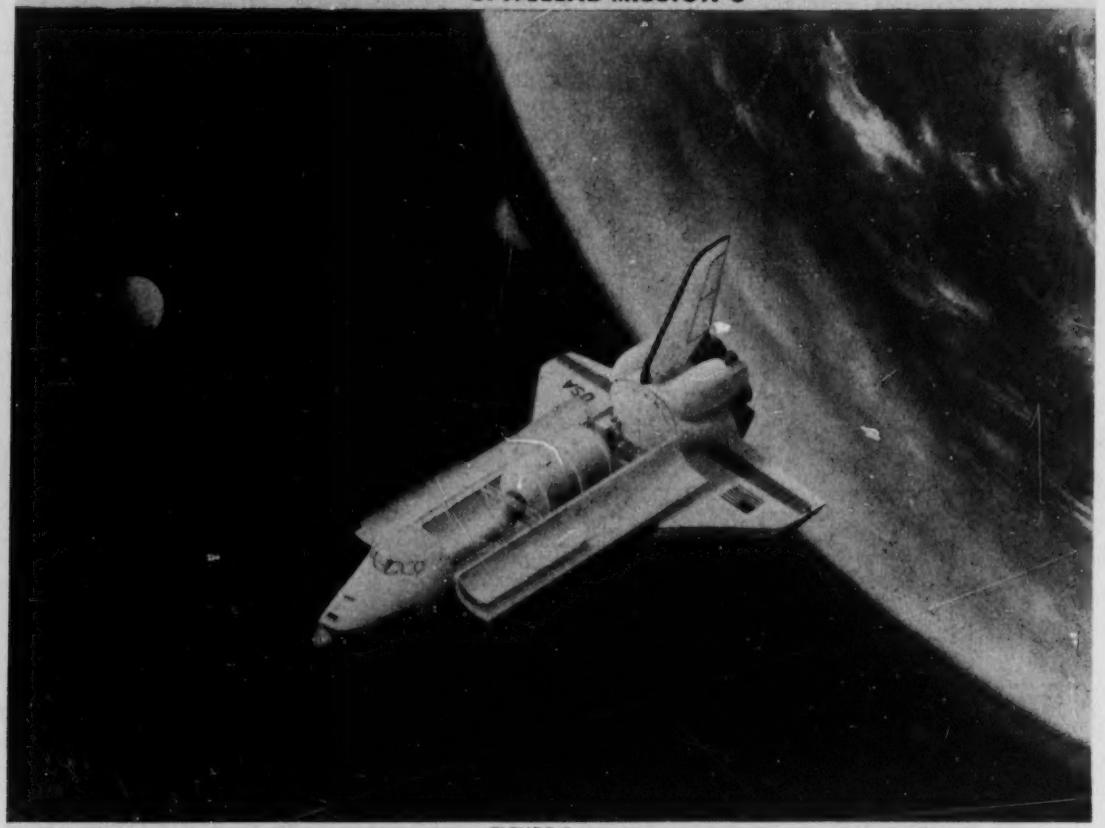

FIGURE 7

SPACELAB 3 INVESTIGATIONS/FACILITIES

DISCIPLINE	TITLE	PRINCIPAL INVESTIGATOR/ DEVELOPMENT CENTER
MATERIALS PROCESSING	FLUID EXPERIMENT SYSTEM VAPOR CRYSTAL GROWTH SYSTEM MERCURY IODIDE CRYSTAL GROWTH	LAL–ALA A&M/MSFC SCHNEPPLE–EG&G/MSFC CADORET–CNES/FRANCE
TECHNOLOGY	DROP DYNAMICS MODULE	WANG–JPL/JPL
ENVIRONMENTAL OBSERVATIONS	ATMOSPHERIC TRACE MOLECULES SPECTROSCOPY GEOPHYSICAL FLUID FLOW CELL	FARMER–JPL/JPL HART–MSFC/MSFC
LIFE SCIENCES	URINE MONITORING SYSTEM RESEARCH ANIMAL HOLDING FACILITIES	SCHNEIDER–JSC/JSC TREMORE–ARC/ARC
PLASMA PHYSICS	IONIZATION STATES OF SOLAR AND GALACTIC COSMIC RAY HEAVY NUCLEI	BISWAS–TATA INSTITUTE/ INDIA

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FIGURE 8

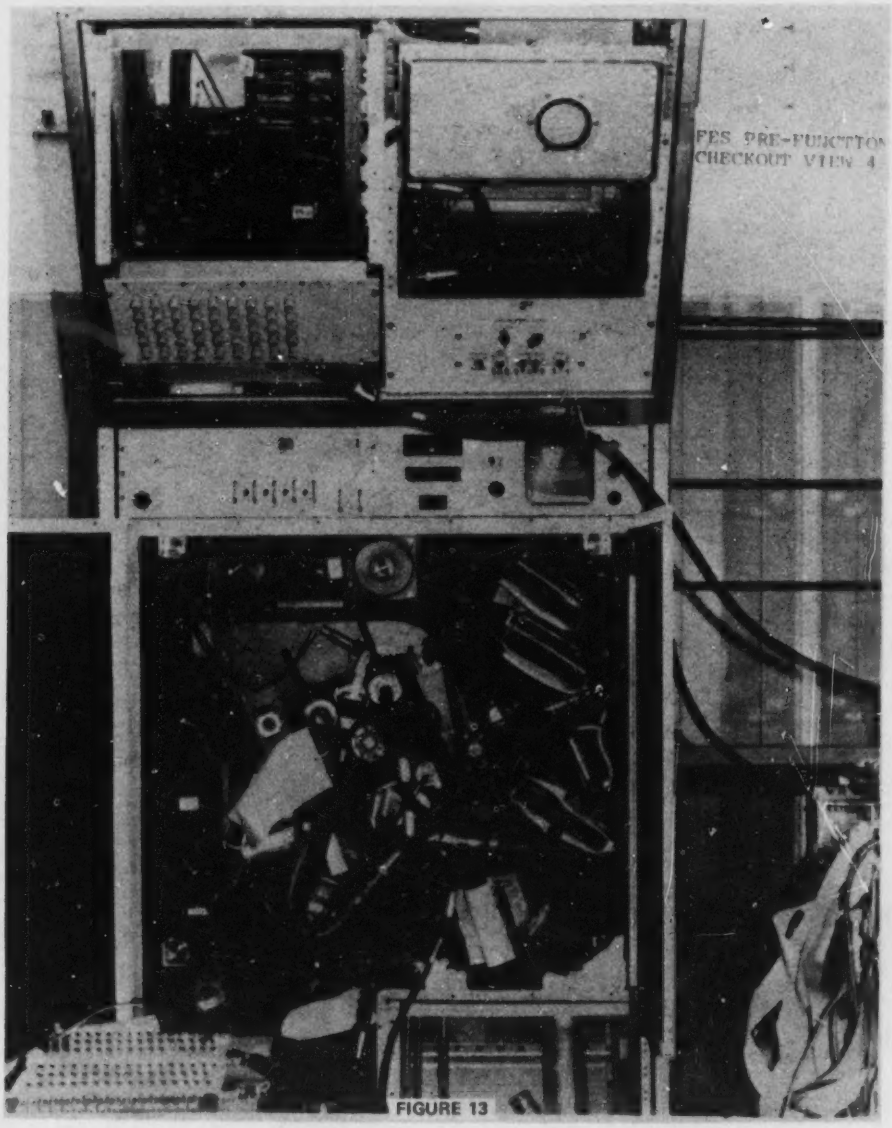


FIGURE 13

FIGURE 14

CONCLUDING REM RKS OF OFFICIALS OF THE GEORGE C. MARSHALL SPACE FLIGHT CENTER

Chairman VOLKMER. I would like to ask if you are satisfied that we will be able to provide the main engines on time, say right now, for proposed flights this year?

Mr. LINDSTROM. Mr. Chairman, during this fiscal year, we do not have any designated spare engines. We are going to have to provide spares from engines allocated to the next Orbiter flight. So any difficulties on any one of two engines could cause us some problems in support of the flight program. In 1984, we start to get better in terms of spare engines and components availability; 1983 is going to be very tight from a hardware standpoint. Any additional problems such as we are currently having, although they themselves may not be a major technical issue, would cause schedule difficulties and could very well impact our flights for the remainder of this year.

Chairman VOLKMER. After this from now to 1984 to 1985 or up to when you get to 16 or 24, you do not see any problems?

Mr. LINDSTROM. In 1984 we achieve a much more favorable situation in terms of hardware. In our budget request we are asking for additonal hardware in 1985 and 1986 to improve that posture.

Chairman VOLKMER. Ronnie, do you want to get on with this SRB thing a little bit? Do you mind if I do?

Mr. FLIPPO. Be my guest.

Chairman VOLKMER. I would like to ask on the SRB a hypothetical question. If you had the facility already available at both Huntsville and Kennedy, which would be the best place to have it?

Mr. LINDSTROM. Let me explain that. The SRB project is located currently in both Huntsville and at Kennedy.

Chairman VOLKMER. I understand that.

Mr. LINDSTROM. In Huntsville, we have the engineering, logistics, procurement, and so forth. In terms of a manufacturing facility or a facility for refurbishment and assembly, the most efficient location would be right near hangar AF on Cape Canaveral Air Force Station, if there are no other considerations such as schedule and cost. We have been considering the facilities on the Cape Canaveral Air Force Station, which would provide an integrated facility in conjunction with the hanger AF at the disassembly facility. We have studied those options over the last year or so.

Chairman VOLKMER. When do we anticipate that we are going to have a full resolution of the problem on refurbishment?

Mr. LINDSTROM. We are currently conducting studies and expect to complete these in the coming weeks.

Chairman VOLKMER. By the end of March?

Mr. LINDSTROM. I believe so.

Chairman VOLKMER. For my own personal understanding, once a booster is brought in and refurbished, the propellant, and so forth, is going to have to be added, right?

Mr. LINDSTROM. Let me explain that. There are two refurbishment facilities: one is for the solid rocket motor, the large casting segments; they are disassembled at Kennedy and shipped to Brigham City, Utah.

Mr. FLIPPO. Bob, excuse me just 1 minute. Can we have a chart up here. You had a chart that showed the SRB. Could you get that back up, and can we get a look at what has to take place for refurbishment, since I know that the Chairman is extremely interested in that at this time.

Mr. LINDSTROM. I'm afraid they have taken my viewpoints back.

Chairman VOLKMER. All right, that's all right, just explain to me. I understand now the answers are in agreement.

Mr. LINDSTROM. The four large casting segments are shipped to Utah to be refurbished. The forward unit and the aft skirt are refurbished at another location. They are disassembled in varying states and reinspected. Components are reacceptance tested, combined with new hardware, about half of the hardware each time in terms of total cost is new; new cables, and other components that aren't reusable. It's again reassembled, checked out, put in a complete state, and turned over to the launch crew.

Chairman VOLKMER. In other words, the aft and forward end may end up with another set of boosters.

Mr. LINDSTROM. That's correct.

Chairman VOLKMER. Or a refurbished set of boosters from the year before, is that correct?

Mr. LINDSTROM. That's correct. In many cases from one flight, the forward unit from one bird may go to flight 10, and the aft skirt may go to flight 11.

It is a major logistics program in terms of keeping track of hardware. Also, the aft skirts and the forward units from the Vandenberg launches would be returned to this facility, so there is a major logistics program in terms of refurbishing the hardware.

Mr. LUJAN. Would you send the motor to Utah, in either case?

Mr. LINDSTROM. In any case, the motor goes to Utah.

Chairman VOLKMER. So we're talking about the aft assembly and the forward assembly?

Mr. FLIPPO. And these are for launches from both Kennedy and Vandenberg?

Mr. LINDSTROM. Yes, they are used for launching at both sites, Kennedy and Vandenberg.

Chairman VOLKMER. What are the major challenges that you see with the production schedule that you have for the new refurbishing, of being able to have the capability for 24 a year by 1986, 1987?

Mr. LINDSTROM. In 1987, and we need production capability about 1 year earlier. The vehicle assembly building and other facilities are good for 16 per year. We achieve this rate in late 1984, so we need to increase production capacity by that time. I am, again, only talking about the aft unit and the forward unit.

We have the requirement for an efficient facility, for an efficient, quick turnaround. We have a problem of not having sufficient hardware; as I mentioned, we are trying to procure additional SRB hardware. If we are in an inefficient facility, it takes us a long time to turnaround and this impacts the hardware needed. We have had damage to the aft skirts and have had to redesign to eliminate the damage. This redesign will, in time, shorten the turnaround time. So we have three major issues: Inefficient facilities, procurement of additonal hardware, and completion of redesign and recertification.

Chairman VOLKMER. Now Thiokol makes the motor, there's no problem with that?

Mr. LINDSTROM. Thiokol makes the motors. There's no problem with that production capacity.

Chairman VOLKMER. No issues once you get to 24? Or do they have the capability?

Mr. LINDSTROM. Thiokol has the capability, and they finance the facility themselves. There is one facility they are currently putting in with their own funding. This is a weather shelter over the casting pit. It will allow for them to have a more efficient and better operation in the very cold Utah winter months.

Chairman VOLKMER. Now what is going to be, this may be a rather difficult question here, the full investment in the tooling equipment, facilities required to increase the solid rocket booster capability, which existed at the end of the development stage, since then, to the operational capability of 24 flights a year in 1987. About how much?

Mr. LINDSTROM. You're talking about facilities and tooling?

Chairman VOLKMER. Right.

Mr. LINDSTROM. It depends upon the final location, but the range will vary from $60 to $70 million.

Chairman VOLKMER. Are those figures integrated in the 1984 or 1985 proposed budget?

Mr. LINDSTROM. They are in our proposed budget, the dollars are.

Chairman VOLKMER. Except you don't know where the facility is going to be, so you don't know how much it will be.

Mr. LINDSTROM. There will be a variance once the final decision is made, right?

Mr. LUJAN. You say between $60 and $70 million?

Mr. LINDSTROM. Well, some options involve the use of existing buildings, and some involve construction of completely new facilities.

There are differences, but it's in that region. We are looking at several different options in between. They vary.

Chairman VOLKMER. Now Michoud is a Government-owned facility, contractor-operated, right?

Mr. LINDSTROM. Michoud is a Government-owned facility, contractor-operated, that's correct.

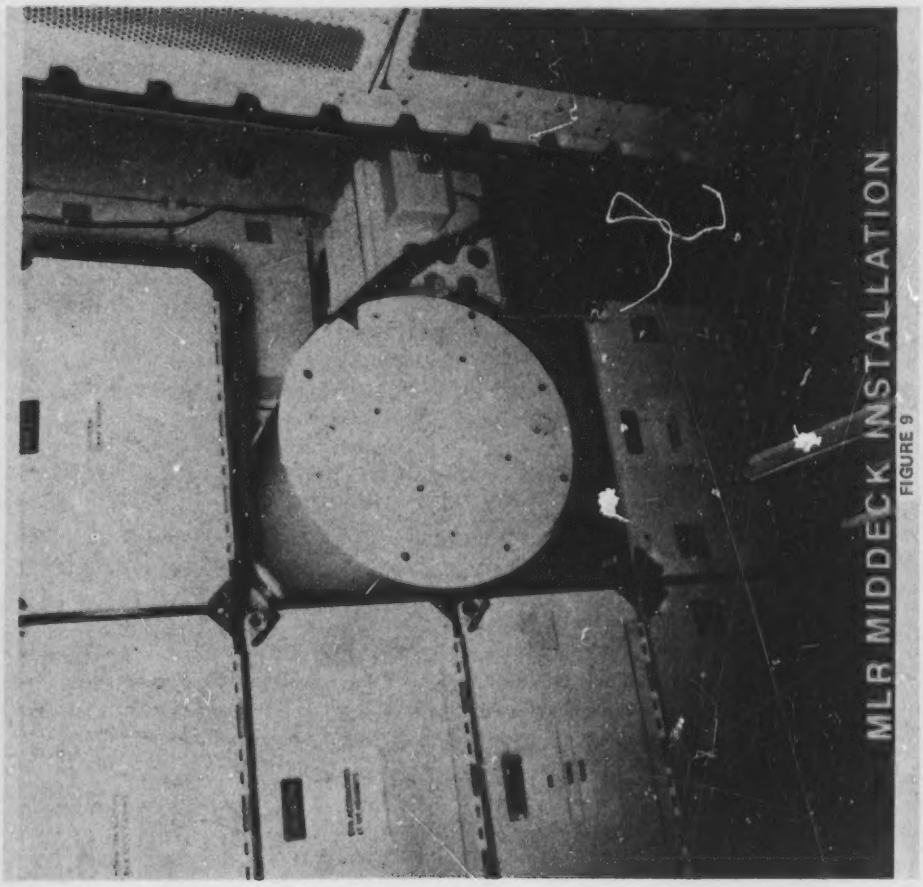
Chairman VOLKMER. That was done for a reason. So that you could have possibilities of rebidding?

Mr. LINDSTROM. That is one of the features. The Michoud facility was built by the Government during World War II. At the time of the Saturn program, it was an existing facility. Primarily, it was used because it was an existing facility with water transportation. But it does perhaps enable you to recompete more easily.

Chairman VOLKMER. Do you anticipate recompeting actually?

Mr. LINDSTROM. We have no firm plans at the present time. We have considered recompeting various elements, recompeting the inter tank, which is a large structural assembly; taking that out of their contract, and letting contractors bid on that. And certainly break-out buys where we may take one part of that tank will be considered as we get into heavier production.

Chairman VOLKMER. You mean you would direct subcontract?



MLR MIDDECK INSTALLATION

FIGURE 9

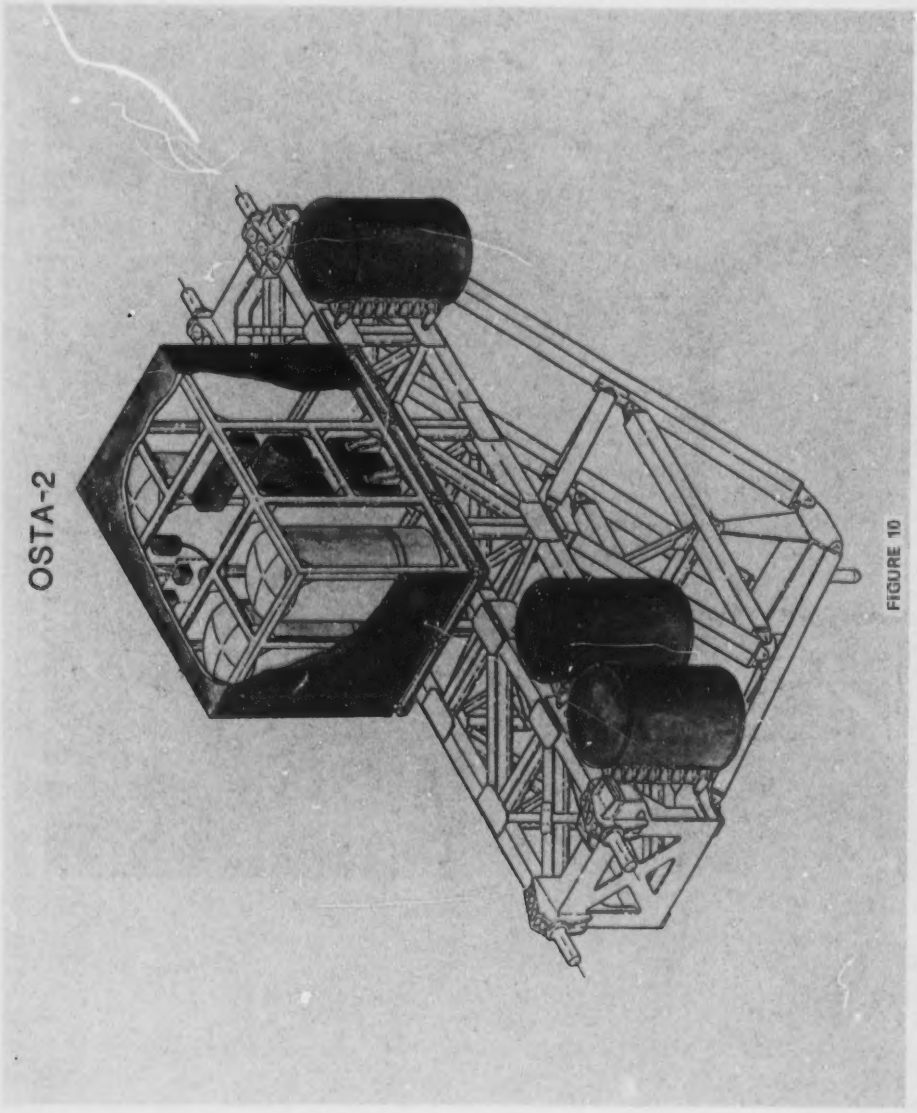


FIGURE 10

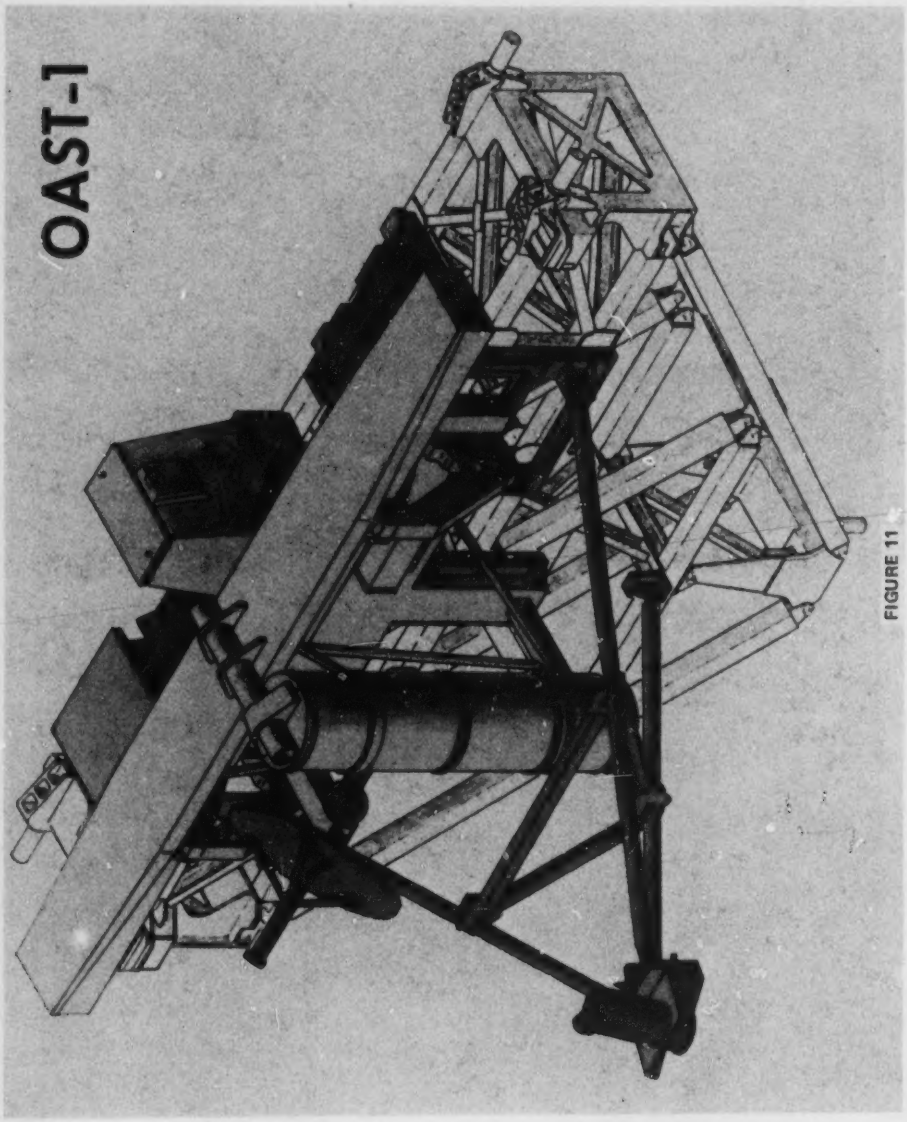


FIGURE 11

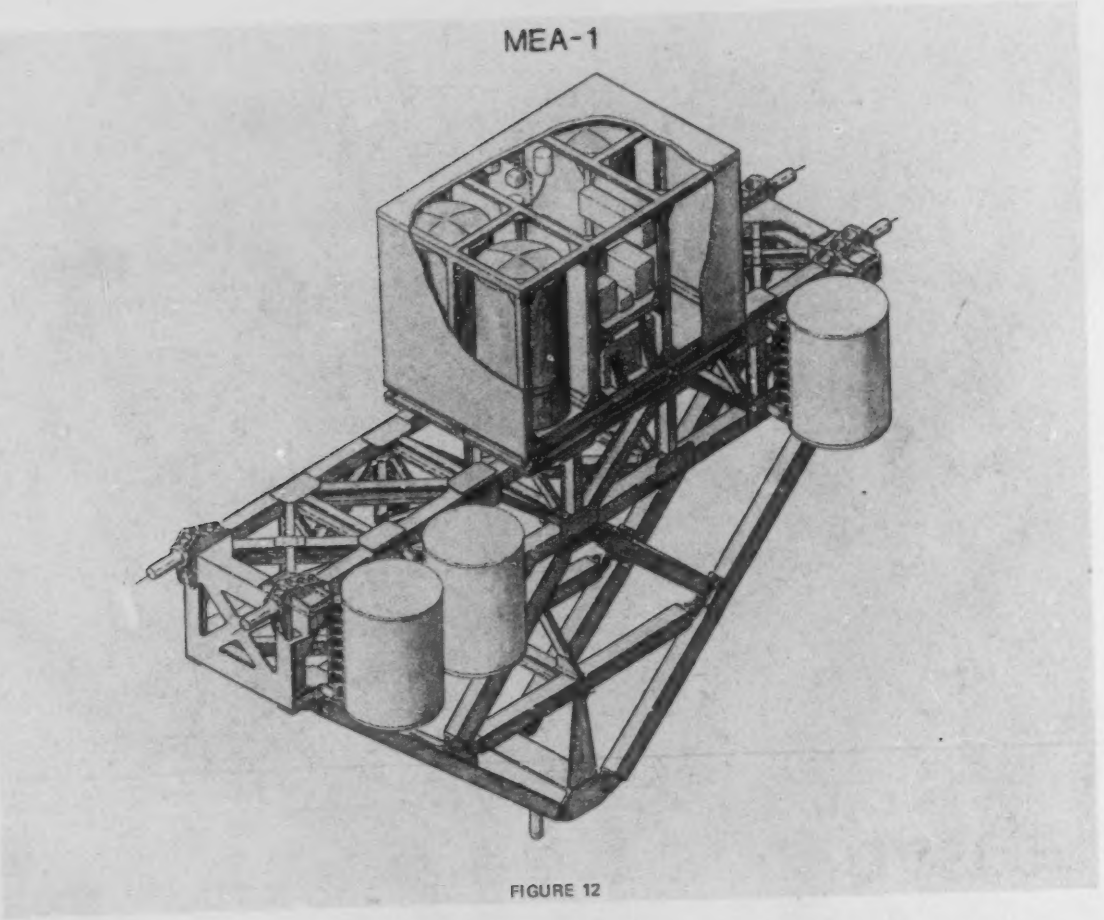


FIGURE 12

Mr. LINDSTROM. We would do our direct subcontracting as is typical of Department of Defense procurements. After a system is developed they will advertise part of the procurement to multivendors in order to get competition. We have no firm plans at this time.

Chairman VOLKMER. If the SRB refurbishment facilities were to be located here, would this increase the amount of shipments, in other words, that you are going to have to make of the assemblies aft and forward?

Mr. LINDSTROM. Yes, sir, the aft assemblies would have to be transported by rail and the forward transported by truck to the Kennedy Center and subsequently back here. These assemblies are flown to Vandenberg by C-5A, so that in terms of the Vandenberg launch, it is just a shorter flight. But there would be more transporation.

Chairman VOLKMER. How is it done now? Is it all done in Utah?

Mr. LINDSTROM. The motors themselves, those four large casting segments are made individually in Utah, and shipped by rail.

Chairman VOLKMER. Where is it assembed?

Mr. LINDSTROM. It is assembled on the mobile launcher. To stack the vehicle, we place the aft assembly, then four casting assemblies, and then put on the forward assembly. The external tank is lowered between and the Orbiter is mated to the tank. The assembly is done on the mobile laucher.

Chairman VOLKMER. Will you do that even with the refurbishment?

Mr. LINDSTROM. That will be done in any case. The assembly will always be done on the mobile launcher, it's part of the launch operation.

Chairman VOLKMER. There's no problem with that, that won't change no matter where it is, that doesn't make any difference there?

Mr. LUJAN. Now I've asked this before, I asked the same thing at Michoud, and I'll ask you too: Were there not some questions raised by the aerospace safety advisory panel concerning the lightweight external tank?

Mr. LINDSTROM. There was some consideration of structural testing, whether we had tested that completely. I believe that has been clarified. Mr. Kingsbury, would you like to comment on that?

Mr. KINGSBURY. There was a question of buckling instability raised by one member of the panel. I think partly because he didn't fully understand what had already been done. He did suggest that we do an analysis that we had not done, and we are doing that.

Chairman VOLKMER. How long before you complete that analysis?

Mr. KINGSBURY. It should be finished in March.

Chairman VOLKMER. In the meantime, the first lightweight tank is going to be used on STS-6, right?

Mr. KINGSBURY. Yes, he didn't have any concerns about flying it on STS-6. His concern was about flying it with the 109-percent engine. We're quite a ways away from that. For the 104-percent engine, we have demonstrated by a test a safety factor of 1.18. We knew we had a good margin, he agreed with that.

Chairman VOLKMER. What are the current SRB costs per unit?

Mr. LINDSTROM. I cannot tell you just exactly, but we will provide that to you for the record. We will be able to provide it later.

Mr. LUJAN. Well, just a rough idea of what it costs, a brandnew one, and you know what the cost is to refurbish it?

Mr. LINDSTROM. A brandnew flight set of boosters completely loaded with propellants and all their components will problably be in the range of $60 to $70 miilion with the propellants. And the flight set refurbishment will be in the range of $25 million. We anticipate 20 reuses of most of that hardware.

Chairman VOLKMER. We received in the ET testimony at Michoud that they saw no problems in reaching the 24-a-year timeframe required. With the facilities that are existing, except the changeover which they said will take about 2 years to get them within the flight, do you agree with that?

Mr. LINDSTROM. Yes, sir. We share that assessment.

Chairman VOLKMER. I have no further questions.

Mr. FLIPPO. Mr. Chairman, may I ask a question here? At Michoud you are building new facilities to get up to the rate of production on the external tank. How long from the time you decided to construct those facilities, did it take in design, and to complete construction?

Mr. LINDSTROM. There are a number of different facilities, but I would imagine that the typical contract time is about 3 years.

Mr. FLIPPO. I'm really referring to, I think we were talking about a $10 million expansion if it was offsite and about $15 million onsite, at Michoud or something along those lines, a bit of speculation there, but the construction on Government facilities there of that $10 or $15 million expenditure you think would run about 3 years?

Mr. LINDSTROM. I believe that is about right, from the time you start initial design, request the funding.

Mr. FLIPPO. And the size of the facility for refurbishment of the SRB's in Florida, any offsite facilities or onsite facilities, is it a $10 to $15 million expenditure, in that neighborhood?

Mr. LINDSTROM. Offsite is in the neighborhood of $20 million.

Mr. FLIPPO. I see, OK. The final construction, do you have any concept about offsite or onsite down there?

Mr. LINDSTROM. The construction offsite would be somewhat quicker. USBI has been working an offsite facility several months and they have brought on the A-E firms and done a good deal of design and site work in that time. Additionally, offsite they would construct with their own funds and would not have to comply with all the Government regulations. They would not use Davis-Bacon labor for an onsite facility. An onsite facility may take a little longer and may require some additional funds.

Mr. FLIPPO. When you looked at offsite facilities at Michoud, the agency decided to build on Government property at Michoud, I think.

Mr. LINDSTROM. Yes, sir.

Mr. FLIPPO. Even though the cost is considerably more than anticipated, more than building offsite.

Mr. LINDSTROM. Yes, sir.

Mr. FLIPPO. And so if the agency was consistent in its approach to the SRB problems, it would consider constructing facilities on

Kennedy, I suppose, and/or some alternative to that. I suppose that the same logic and reason applied to the external tank facilities would apply to the SRB, since they're both part and parcel of the same propulsion system. Probably, is that reasonable?

Mr. LINDSTROM. I am not in a position to comment on the basis for the agency position.

Mr. FLIPPO. Thank you very much, I appreciate it.

Chairman VOLKMER. I have no further questions. Do you have anything you want to say, Dr. Lucas?

Dr. LUCAS. Mr. Chairman, this concludes what we had expected to present this morning, and the afternoon will be devoted to a tour, if that meets your requirements. We are available to answer any more questions that you may have.

Chairman VOLKMER. I have no further questions.

1984 NASA AUTHORIZATION

TUESDAY, MARCH 1, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 1:35 p.m., in room 2325, Rayburn House Office Building, Hon. Harold L. Volkmer (chairman of the subcommittee) presiding.

Present: Mr. Volkmer, Mr. Nelson, Mr. Brown, Mr. Dymally, Mr. Mineta, Mr. Lujan, Mr. Chandler, Mr. Lowery, and Mr. Walker.

Mr. VOLKMER. The subcommittee will come to order.

This hearing is part of our continuing review of the NASA fiscal year budget request. Today we will focus on the Office of Space Flight and review NASA's budget request for space shuttle-related activities.

We are concerned with NASA's efforts to increase the shuttle flight rate capability while at the same time reducing operational costs. The continuing problems at Kennedy Space Center point out the need for adequate spare engines and spare parts to assure that the shuttle can provide a reliable operational capability. We are also concerned that a limited orbiter fleet size, in concert with the priority afforded national security payloads, serves to strengthen the competitive posture of foreign launch systems. Finally, we will review NASA's budget request for advanced programs and NASA's space station activities.

Our first witness is Lt. Gen. James Abrahamson, associate administrator for the Office of Space Flight, who will be followed by Mr. John D. Hodge, Director, Space Station Task Force.

At this time I will ask General Abrahamson to proceed. You have a prepared statement that will be made a part of the record, and if you wish to give us a synopsis of it or an outline or follow the full statement, whichever you prefer, we do have one member who has a time constraint. Please proceed however you desire, though.

[A biographical sketch of General Abrahamson follows:]

LT. GEN. JAMES A. ABRAHAMSON

Major General James A. Abrahamson became NASA's Associate Administrator for Space Transportation Systems in November 1981. He is on assignment from the Air Force. His major task will be to oversee Space Shuttle development. His previous assignment was Deputy Chief of Staff for Systems Command at Andrews Air Force Base, Md.

General Abrahamson has long been involved in the Air Force and NASA's space progams. In August 1961, he was assigned as spacecraft project officer on the VELA Nuclear Detection Satellite program at Los Angeles Air Force Station, Calif. He attended Aerospace Research Pilot School at Edwards Air Force Base, Calif., and became an Air Force test pilot in 1967. He was then selected as an astronaut with

the Air Force's Manned Orbiting Laboratory Program, and was with the program until its cancellation in June 1969. Then he was selected to serve on the staff of the National Aeronautics and Space Council in the Executive Office of the President of the United States. Most recently, in 1979, he was chosen by NASA for a special team charged with assessing the management of the Space Transportation Systems.

General Abrahamson was commissioned a second lieutenant in the Air Force in November 1955 and completed pilot-training at Laughlin Air Force Base, Tex., in May 1957. His initial duty was as an instructor in the Air Training Command. From October 1964 to August 1965, Abrahamson served two temporary duty tours in Southeast Asia where he flew 49 combat missions.

In March 1971 he was reassigned to Air Force Systems Command as the director for the TV-guided, air-to-ground Maverick missile program at Wright-Patterson Air Force Base, Ohio. He commanded the 4950th Test Wing at Wright-Patterson from June 1973 until March 1974 when he became inspector general for the Air Force Systems Command. He was then assigned as director for the F-16 air combat fighter program at the Aeronautical Systems Division at Wright-Patterson in May 1976. Abrahamson assumed his duties as Deputy Chief of Staff for Systems in July 1980.

General Abrahamson was born May 19, 1933, in Williston, N.D. He attended secondary schools in Oregon and graduated from the Massachusetts Institute of Technology, Cambridge, in 1955. He earned a master's degree in aeronautical engineering through the Air Force Institute of Technology program at the University of Oklahoma, Norman, in 1961. In 1966, he completed Air Command and Staff College at Maxwell Air Force Base, Ala., as a distinguished graduate. Abrahamson is a command pilot with more than 3,000 flying hours in conventional and jet fighter aircraft. His military decorations and awards include the Distinguished Service Medal, Legion of Merit with one oak leaf cluster, Meritorious Service Medal. Air Force Outstanding Units Award ribbon and the Air Force Organizational Excellence Award.

He was promoted to major general May 1, 1978, with date of rank Sept. 1, 1974.

General Abrahamson is married to the former Barbara Jean Northcott of Morgan Hill, Calif. They have two children: Kelly Anne and James A. III.

STATEMENT OF LT. GEN. JAMES A. ABRAHAMSON, ASSOCIATE ADMINISTRATOR FOR THE OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY JESSE W. MOORE, DEPUTY ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT; L. MICHAEL WEEKS, DEPUTY ASSOCIATE ADMINISTRATOR (TECHNICAL), OFFICE OF SPACE FLIGHT; AND M. J. STEEL, DIRECTOR, RESOURCES AND INSTITUTIONS OFFICE, OFFICE OF SPACE FLIGHT

General ABRAHAMSON. Mr. Chairman, we were delighted that you could take the time to visit some of our facilities. I think a trip can tell the story of the whole effort much better than any testimony we can present here.

Rather than read the entire statement, I would like to present it for the record. Before I enter into a discussion on the engine, which I would like to start just right off, I would like to make one point.

In spite of the engine problems themselves, we feel that the STS as a system is beginning its operational phase in a successful way, and that we should maintain a useful perspective over and above our short schedule delay. We feel we are entering the operational phase of the program and that the shuttle's success to date represents a tribute to all of the people who are part of this team, both the NASA members and the contractors who have made this possible. Further, their success demonstrates that the United States, our economic system and our technology is capable of moving into this new portion of space age. This is an exciting age, and the shuttle is an important part of what that future may be.

Also, we would like to thank this committee for a very long period of very steadfast support to the program itself. It is that

steadfast support, through times of both trials and triumphs, that has been a very important factor in making this system successful.

With that, I would like to submit my statement for the record. However, I would like to spend a few minutes on our recent engine problems. It will be an update.

This is the picture of the engine itself (fig. 1), and, as I think many of you are familiar, we have had three leaks that have occurred at a time in the program when we were both embarrassed and concerned that they should appear so late in the whole preparation for flight process. However, I would like to underscore that they did occur on the ground. They did occur in such a way that our networks of tests successfully caught those problems and they did not develop during flight.

Most of the problems were small leaks. In all likelihood, they would not have developed into any kind of a catastrophic situation. However, if any one of the leaks had gotten significantly worse, it could have been more of a problem. Therefore, we have to underscore that even though this situation is troublesome to our launch schedule, it is a positive statement about the conservative approach that we have taken on the shuttle, that we caught these engine problems prior to flight.

Another point of perspective is that these engines are not the same engines that flew on the *Columbia*. These are upgraded versions of *Columbia* engines. They have 147 different changes from *Columbia* engines and, in a sense, this is the first operational trial of these upgraded engines. Therefore, you should expect that even though the engines were well into the certification process; some bugs should be expected.

Of the three leaks that we had, the first was on the engine manifold (fig. 2). We found it after the flight readiness firing, which we had added to the overall test sequence because we felt the need to be conservative in examining the system as an entire system. The leak was specifically located after the second flight readiness firing. This was a fairly large leak; but it was only considered to be a definite hazard during a few seconds in the upper part of the flight regime.

The second leak was in the oxidizer turbo pump and was a miniscule one. It was, in fact, on the order of one part in a million, that is very, very small. However, this was the most dangerous of the three because it was in a particularly critical area. Had it progressed and become worse, it could have caused an explosion within the oxidizer pump.

The third leak was in a hydrogen line which supplies the engine starting mechanism (fig. 3). This was discovered because we had developed a set of highly diagnostic tests that identified a small leak in one area, around engine No. 2. As the technicians examined that area and continued to doggedly pursue this small concentration of hydrogen, we finally located the specific leak.

I saw the problem on an engine mounted on the *Challenger*. I was at the pad, looking through a boroscope and checking the conditions under which the technicians had to work. It is a real tribute to these people, the way they continued to pursue the problem until they solve it.

Again, this leak, in its present state, would not have been a serious problem. In fact, the rate was about a third of the leak rate we had in the *Columbia* during every flight. However, had it gotten worse, it would have been serious. Further, it was a generic problem and it had to be repaired on all engines. Therefore, we are making comprehensive repairs and not stopgap measures.

The first leak resulted from a welding procedural deficiency. It was related to the engineering of that weld and was, in fact, a misunderstanding of the heating environment caused during the welding process.

The second leak was in the heat exchanger. Again, the cause was deficient welding on a part that was fabricated in 1977. Many of these are old parts and the shortage of parts has been a contributing factor to the entire series of problems.

The last leak occurred where a hydrogen line goes into the engine. There is a sleeve brazed to the outside of this hydrogen line. It goes through a pressure dome, and we experienced a very small leak through the sleeve. This wasn't the problem; however, the real problem was a crack inside the line that went about half way around. Had that crack developed sufficiently to break off, then the raw products of combustion would have escaped, along with very high-pressure hydrogen.

There were other engines that experienced this type of problem that had been tested extensively. For example, engine 2014, the certification engine, had 8,000 seconds of operation with this same condition, and engine 2010 had 10,000 seconds, neither had leaks. The brazed joints held even though they were cracked, so I am not saying that it would have been a major problem, but we still felt it had to be changed.

What have we learned and what are we doing about it? The first thing is that the responsibility for this set of problems is one that all of us must bear; it starts with the NASA team including the contractor members, and it starts with me. There clearly are some things that we can and should be doing better, and we are going to insure that we learn from this particular set of problems.

The first lesson is to insure that we have enough engine spares (fig. 4). We are, very short of them at this point in time. We must very carefully balance engine spares, so that we can get through 1983. We will be better off in 1984 and 1985, primarily because of investments made in 1982 and 1983, Additionally, rather than proceed with the full power operation of engines—109 percent—on the eighth flight, in line with our initial planning, we have now limited the operation of the engine to 104 percent until we need greater power settings at Vandenberg Air Force Base in October 1985. That allows the engine to be operated at a lower stress level which will preserve our spares for a period of time. Making that decision has also allowed us to relax our certification schedule and to avoid diverting spares to support certification tests.

Further, we need to add margin to our production line. Because, as I indicated, the absence of hardware was one of the fundamental problems. We are increasing what we call bank time, which means that when you finish one part of the assembly process, you have additional time prior to the period that any one component is needed, for the next assembly operation. This provides a margin, so

that problems can be solved in the production line without disrupting the flow.

We are also adding manufacturing attrition components. Previously when there was an item damaged in the production line, we did not have other components that could be put in as replacements. Thus they had to be reworked. That rework decision had to be effected quickly. This was a contributor to the deficient repair engineering that I previously discussed.

What we are now doing is to add some components for this, so that we can have an extra power head or an extra pump, which would then be available to keep the production line moving in a smooth fashion. Adding these now will not help the production line until downstream, about a year or two, but it will make a positive difference for the future.

We have also developed improved leak tests; and, they are now being implemented in all phases of the program. The aim is to test so that we can catch the types of problems I have depicted early in the process rather than on the launch pad. We must also use improved quality and manufacturing engineering. We have a series of team investigations some by the contractors and some by NASA people, in order to try to improve these areas.

These are some of the lessons learned from our challenger engine problem. As painful as it may have been, we, indeed, will have a better program in the future. We will be better able to handle increased flight operations.

With that as an update, I would like to a summarize our budget (fig. 5). I will not comment on the chart; but, instead, I propose to turn it over to you for questions. Our total budget in R&D is depicted. In addition to that, we do have R&PM funds of some $574 million. We have shuttle reimbursable income for standard service that we anticipate at $264 million; and, we do have COF funding, amounting to $71 million.

With that sir, I will be pleased to respond to any questions that you may have.

[The prepared statement, plus answers to questions asked of General Abrahamson follows:]

STATEMENT OF LT. GEN. JAMES A. ABRAHAMSON, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT NATIONAL AERONAUTICS AID SPACE ADMINISTRATION

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before you to present NASA's Office of Space Flight's FY 1984 budget request. The primary responsibility of the Office of Space Flight (OSF) is to establish a fully operational cost effective National Space Transportation System as quickly as possible. To this end, we are requesting $3.498 billion in FY 1984 for Space Transportation Capability Development and Space Transportation Operations.

There is little that I can add to the volumes that have been said and written about the Space Shuttle since its inaugural flight nearly two years ago, except to say that in nearly every aspect it has exceeded the hopes and expectations that anyone had for it. The men and women who worked for it with selfless dedication over the years to turn this idea into a reality earned the praise they have received. The members of this Committee through their support, encouragement and their patience through the problems which we went through are already members of this team which brought the Space Shuttle to fruition. Together, we have successfully completed the initial phase of this considerable venture. With this phase behind us, we must now focus our attention on the work to be done over the next several years to make this system fully operational.

The past year marked not only the completion of the orbital flight tests and the initial operational flight, but also the delivery of the second flight orbiter, Challenger. The delivery of Challenger on schedule last summer was a major accomplishment for the government-industry team. Challenger is now on the launch pad being readied for its maiden flight. We completed a first flight readiness firing on the Challenger main propulsion system in December and found higher concentrations of gaseous hydrogen in the aft fuselage than we found on the flight readiness firing for the Columbia. A search for the source of the hydrogen, under the best conditions possible without system teardown, did not yield conclusive results. We repeated the Challenger flight readiness firing on January 25 following installation of an extensive instrumentation set. This test validated very low levels of oxygen in the aft fuselage. The leak was found on engine number one which is being replaced with a flight spare engine. We should be able to proceed with a launch of STS-6 in March and to minimize our delays for subsequent flights. Additionally, we are developing operational tests and procedures to insure that future flights will not be subjected to this type of delay. Obviously, we shall not commit to flight until we are totally satisfied that Challenger is safe to fly.

Despite this current problem, the the program is showing signs of rapidly maturing. We are seeing efficiencies in hardware production, mission preparations and operations, and program management across the board. The skill and dedication of the NASA team of contractors and government employees are evident in the delivery ahead of schedule of the first lightweight External Tank; the on-time delivery of Challenger; the progress made to date on the third orbiter, Discovery; and, the progress which is being made in the development of the additional performance of the Solid Rocket Booster, the Main Engine, and the many other program elements. I would like as well to point out the valuable contributions of the Canadians in the development of the remote manipulator system, the European Space Agency in the Spacelab development, and the Department of Defense in the development of the Inertial Upper Stage.

In the orbiter production program, we are proceeding with the manufacture of the third and fourth orbiter vehicles. Discovery is now well along in the installation of its thermal protection system and final onboard systems, and delivery on schedule in September of this year appears achievable. The fabrication of Atlantis is also proceeding well, toward its delivery in December 1984. Although this budget request does not include authorization of a fifth orbiter, we are requesting funds to procure additional structural assemblies and components for the orbiter fleet. This will ensure the long-term operational viability of the four-orbiter fleet by providing the capability to repair or replace structural components in the event of damage to those components. This action will also reduce the lead time for expansion or replacement of the four-orbiter fleet should optimistic estimates of demand materialize and other conditions dictate.

The first lightweight External Tank (ET) was delivered ahead of schedule last September. The reduction in weight for this ET over the current tanks was 8,000 pounds--2,000 pounds over the established goal. The changeover in structural tools from the heavyweight to the lightweight configuration was also completed successfully. Based on heating data obtained during the initial flights, we have been able to reduce the amount of thermal protection applied to the tanks. This change, coupled with improvements in the techniques for applying insulation to the surface of the tank and its components, will assist us in achieving the reduction in the number of manufacturing hours to build a tank that we had previously projected. We are also making a major effort to improve the production flow and tooling at the Michoud Assembly Facility to ensure that the required increases in production build rates can be reached. This has been a subject of considerable interest to you and the other NASA committees. At the request of Congress, a team from the National Research Council (National Academies of

Science and Engineering) is working with NASA to validate what needs to be done in this area as well as others to meet the higher flight rates of the future.

The Solid Rocket Boosters (SRB's) have performed to specifications on the ascent phase of each flight, although there has been more water impact damage than anticipated. The loss of the STS-4 boosters due to problems experienced with the parachute deployment was unfortunate and costly, but the problem was resolved in time for STS-5. We are continuing to work on changes to the SRB, and particularly to the aft skirt, that will reduce the water impact damage to a minimum level. Significant progress has been made in the development and readiness for flight of the new high performance motor this year. We anticipate a payload carrying capability increase of 2,000 pounds from this effort. As in the ET program, we are reviewing the future facility and equipment requirements for the SRB. We are particularly concerned with the question of refurbishment facilities, and how we can best meet the future needs for faster and more cost-effective refurbishment of reusable hardware.

The Space Shuttle Main Engines (SSME) have set an excellent flight record, demonstrating the reuseability for which they were designed. Columbia's engines are now being disassembled and inspected. Afterward, they will be rebuilt to the full power level and returned to service. Difficulties have been encountered in the Full Power Level (FPL) development and certification testing requiring that we acquire one additional engine and sufficient long-lead hardware to replace engines and components lost in test incidents. We have accelerated the production schedules to meet orbiter delivery dates and provide one spare engine per orbiter, as planned.

Flight operations of the Challenger will use the more powerful SSME full power level configuration engine rated at 104%. Three of the four certification cycles on this configuration have been completed and completion of the fourth cycle is expected this spring. Our ground test fleet leader for this configuration has now accumulated over 40 test firings with nearly 15,000 seconds of cumulative service (30 missions).

The principal launch capability developments at the Kennedy Space Center (KSC) last year included the activation of the second orbiter processing facility bay and the second mobile launcher platform to allow processing two orbiters simultaneously. The second set of vehicle assembly building bays and a DOD-secure third firing room will be activated this fiscal year.

Major strides have been made in strengthening management of launch and support operations at the KSC. An important step was the award of a Base Operations Contract (BOC)

which is already demonstrating the benefits of consolidation of fourteen small individual contracts into a single integrated effort. The BOC which was awarded to EG&G, Inc. last November will streamline the launch support functions. It will provide a clear assignment of responsibilities and will reduce management interfaces.

A second important step in both efficiency and in the concept of a single National Space Transportation System to meet all national requirements--civil, scientific and military--was the release of the Request for Proposals (RFP) for the Shuttle Processing Contract (SPC). This contract, like the BOC, will consolidate separate contractor operations and envisions a streamlined management operation as well. Both the BOC and the SPC are incentive type contracts to further motivate the contractors toward ever improving efficiency while maintaining the required high level of competance. The SPC will provide Shuttle processing at both Kennedy Space Center and at Vandenberg Air Force Base. The advantages we expect to gain by having the same contractor team process the Shuttle at both launch sites are improved reliability, safety, efficiency and operational scheduling. This SPC competition should be complete early this fall, and it represents an important contractual initiative. We have also undertaken additional initiatives incorporating incentive-type contracts in the manufacturing of both the External Tank and the Solid Rocket Booster. We believe all these steps are necessary to achieve the dramatically reduced cost-per-flight to which we are dedicated.

In addition to changes in contract structure, responsibilities and incentives, we are making changes in government overview of contractor activities and in the organization responsible for that overview. In aggregate, we believe that these changes will provide both the opportunity and the incentives to achieve minimum cost per launch--consistent with safe and timely operations.

The past year has been particularly active for the joint USA/European Space Agency (ESA) Spacelab Program. Major milestones were met as the program activities moves steadily toward the first flight in September 1983. In early February 1982, an ESA pallet was used to carry the scientific experiments on the third Shuttle Test Flight (OSS-1). In August 1982, ESA delivered the second flight unit and one set of ground support equipment. In December 1982, the first crew transfer tunnel was delivered to KSC. The tunnel is the first major piece of U.S. developed equipment delivered for use during the first Spacelab flight. At the end of 19??, the complete first flight configuration, including both the U.S. and the international experiments, was being readied for integrated testing.

Upper stage requirements and continuing use of Expendable Launch Vehicles (ELV) have been under scrutiny as the Space Transportation System (STS) grows. The Centaur Upper Stage Program has been reinitiated, and a Memorandum of Understanding was signed with the Department of Defense (DOD) last November by which NASA and the DOD will equally share the design, development, test and evaluation (DDT&E) costs. We have already begun orbiter and launch facility modifications to accommodate Centaur missions. NASA's requirements for the Inertial Upper Stage (IUS) have decreased from six to four as a result of changes in the Tracking and Data Relay Satellite (TDRS) program. The Delta ELV production and launch program has been impacted severely by customers' decisions to opt for Shuttle availability or to use Ariane. These decisions have resulted in a serious ELV funding problem in FY 1983 for which we have requested a reprogramming action in order to accomplish adjusted program plans. Further, we have decided to reduce the number of Delta vehicles being procured and phase down government procurement of the Delta and other ELV's as soon as practical. We will, however, continue Delta launch operations until 1986 to meet the needs of the firm users.

There is a need for an upper stage to meet weight requirements which fall between the Payload Assist Modules (PAM) which are now available and the Centaur. Phase B studies were being prepared by NASA for a Transfer Orbit System (TOS) to meet this need. However, we have received a proposal for private sector development of this system. We are delaying further activity on the funded study pending thorough evaluation of this proposal.

The near future holds great promises as we bring our Challenger into operation and modify the Columbia for the initial Spacelab mission. During the next year, we will use higher performance main engines and solid rocket boosters, provide around-the-clock flight crew operations, conduct our first night launch and landing, perform extravehicular activity, and launch the first dedicated DOD mission. By the end of 1983, five commercial payloads and two NASA tracking and data relay satellites will have been deployed by the Space Transportation System, and thirty-seven crew members will have made flights aboard the Space Shuttle.

We are also paying particular attention to prospective commercial customers who may wish to launch payloads aboard the Space Shuttle. We revised our policy for payload specialists which will broaden the opportunity for Shuttle customers to designate payload specialists to fly when the customer deems it necessary. The final details of this policy are being worked and will, upon completion, be published in the Federal Register.

The program progress, changes and redirections I have discussed are not without funding adjustments. Mr. Chairman, we have attempted to work closely with your Committee as decisions needed to be made, and we are grateful for both your understanding and strong support.

We previously informed this Committee that we were negotiating a revision to the NASA/DOD MOA on Reimbursements for Shuttle missions. We have now mutually agreed to a revision. The major revisions cover: 1) The reimbursement DOD will pay for a standard launch, 2) The definition of standard versus optional services and 3) Mission flexibility to meet DOD operational requirements.

The DOD will pay $16.0 million (75$) for a dedicated mission through FY 85 and 29.8 million (75$) for missions in the FY 1985-88 time frame. DOD and NASA will trade services which can be accomplished by the organic manning at each site. Services beyond organic capability will be provided at additive costs. NASA will also receive the important assurance of predictable revenue. Finally, NASA assures DOD of maximum performance flexibility to meet national security requirements.

FY 1984 Budget Request

With respect to the FY 1984 Budget Request, the total budget authority requested for Space Transportation Research and Development activities is $3,498.0 million.

Within the $3,498.0 million overall request, an amount of $1,927.4 million is requested for Space Transportation Capability Development, which includes Shuttle Production, Upper Stages, Spacelab, Engineering and Technical Base, Payload Operations and Support Equipment, the Tethered Satellite System development, and Advanced Programs. For Space Transportation Operations, which includes Shuttle Operations and Expendable Launch Vehicle activities, $1,570.6 million is being requested.

Space Transportation Capability Development

Orbiter

We are requesting $729.6 million in FY 1984 for the Orbiter Program, a decrease of $174.8 million from the current FY 1983 estimate.

These funds will be used primarily to maintain the current production schedule, modifications for the Centaur Upper Stage, systems integration activities and the procurement and fabrication of spares.

Modifications for the Centaur Upper Stage are in design with a Critical Design Review scheduled for late 1983. Modification kits for two orbiters should be completed in early 1985.

Systems integration activities include loads analyses, performance margins assessments, post-flight performance and anomaly analyses, turnaround time reduction, contingency abort analyses and Vandenberg systems integration.

Fabrication of spares, which I mentioned earlier, will include all major structural assemblies, selected structural parts and components. The extent of this assembly will vary. For example, the main fuselage work will be completed up to the point of readiness for installation of the TPS, plumbing, wire harnesses and major electrical, propulsion and hydraulic components. Spares that may be needed quickly in the event of an incident, such as damaged control surfaces, will be completely finished.

Launch and Mission Support

The principal launch capability developments at KSC last year included the activation of the second orbiter processing facility bay and the second mobile launcher platform to allow processing two orbiters simultaneously. The second set of vehicle assembly building bays and a DOD-secure third firing room will be activated this fiscal year.

The FY 1984 funding request of $245.5 million primarily supports the development of these launch processing capabilities at the East Coast launch site and the mission preparations, training, and operations capabilities at the Johnson Space Center (JSC). At the launch site, the key activities to be continued during this period will be: the activation of the second launch pad, the modifications of both launch pads, and two MLP's to support the servicing and launch of Shuttle vehicles with Centaur Upper Stages for the back-to-back planetary missions in May 1986. The related budget request for Construction of Facilities also includes funds for: the third MLP, modifications to the Spacecraft Assembly and Encapsulation Facility, SAEF-2, and the cargo hazardous servicing facility. Equipment for these facilities, the horizontal cargo integration test equipment, and multi-use mission support equipment will be procured with FY 1984 capability development funding.

The FY 1984 funding request will also support the procurement and modification of a third Gulfstream II for use as a Shuttle Training Aircraft (STA), fabrication of the Manned Maneuvering Units, space suits and other training and simulation needs. The third STA is necessary

to insure non-interruption of essential crew training. Also the funds requested provide for the reconfiguration of the Mission Control Center (MCC) at the JSC to meet the STS operational schedules.

Propulsion Systems

For FY 1984, we are requesting $472.2 million to continue production and capability development activities for the SRB, ET, and the SSME. Under this budget, spare hardware is provisioned, overhauled and repaired; crew equipment hardware is acquired and maintained; and, the base support for the liquid hydrogen plant is furnished. Orbiter, main engine, and crew equipment spares are procured based on calculations involving flight rates, mean-time between failure, maintenance schedules, operational hours, turnaround time and lead time to procure spares.

The development of a Filament Wound Case (FWC) to provide additional Shuttle performance was initiated in May 1982. Hercules, Inc., and Votaw Precision Tool, Inc., in a joint venture were selected to be the subcontractors to Thiokol (the prime contractor) for the FWC design, development, test and delivery of six flight motor cases. These cases will provide a polar launch capability increase of approximately 5,500 pounds. The first full scale test motor will be delivered and test fired in FY 84. The first flight use of FWC motors is expected early in FY 86.

In FY 1984, a marked increased in ET production is expected. The delivery rate and flight rate will be ten and nine units, respectively. By the end of the year, at least 16 tanks will be in manufacturing flow. Facility and tooling buildup will continue. We will also continue our efforts to reduce cost production costs. Meeting required production rates and buildup to the higher capability for future years will be given major emphasis.

We are now initiating a critical SSME Flight Confidence Program in which we are repeatedly testing the certification engines to demonstrate their long term reusability. This program is structured to assure that the accumulated operating time in ground test engines always exceeds the flight engine usage by at least a factor of two. The program should uncover any inherent time related weakness in the engines, not revealed in certification or development testing, well in advance of any similar flight problems. We can then make the necessary fixes or other program adjustments to avoid impacts on the flight program. This testing will establish a firm basis for our engine flight maintenance schedules and provide a near term verification of our engine logistics planning.

Changes and Systems Upgrading

The budget request for changes and systems upgrading of $52.7 million in FY 1984 will provide funding for potential changes and systems modifications as well as for unanticipated new requirements not covered in the budget estimates for the activities outlined above.

Upper Stages

The STS Upper Stages are required to carry Shuttle-launched payloads to orbits not attainable by the Shuttle alone. The Upper Stage Program is comprised of Inertial Upper Stage (IUS), the Centaur and the Payload Assist Module (PAM). We are requesting $143.2 million for the Upper Stages Program.

The NASA part of the NASA/DOD IUS Program IUS budget has been revised substantially to reflect the reduction in the planned number of near-term TDRSS launches. We are continuing our support of the Air Force in the completion of IUS development and production on a schedule consistent with the TDRSS launch requirements. No NASA requirements have been identified for the IUS beyond the TDRSS.

NASA and DOD have entered into a joint development program of a derivative of the Centaur Stage designated Centaur-G. The Centaur-G will accommodate a forty foot long payload of approximately 10,000 pounds and be capable of placing it into geosynchronous orbit from the orbiter and will be used to launch the Venus Radar Mapper if approved by Congress. A longer versison of the Centaur-G, G Prime, is being developed by NASA for launch of the Galileo and ISPM spacecraft in May 1986.

The funds being requested for FY 1984 are required to continue development of Centaur-G and G Prime and the procurement of two Centaur G-Prime vehicles to support the Galileo and ISPM missions.

Fabrication of test hardware is underway as well as procurement of avionics, electrical and mechanical subsystems. These efforts will continue through 1983 and 1984 with completion of the structural test vehicle planned for June 1984. Structural load tests should continue through September 1984.

As I previously noted, both the orbiters and launch site facilities will have to be modified to launch the Centaur Stage. The key modifications will be to Orbiters 099 and 104, Pads A and B at Complex 39 and MLP-1 and MLP-2.

PAM's are being developed commercially, but NASA monitors the development and production. Eight PAM's have been flown successfully atop Delta launch vehicles, and two were successfully launched on STS-5.

Spacelab

For FY 1984, we are requesting $119.6 million in Spacelab development and operations. The first all-up Spacelab Mission (SL-1), with its manned module and single pallet, is scheduled for launch at the end of September 1983; in FY 1984, we will be doing post-flight systems checkout and data review to verify systems performance and make any necessary changes. The requested funding will also be used to make preparations for the second verification flight of Spacelab which will test the pallet-only configuration (no manned laboratory module) and will be the first flight of the ESA-developed Instrument Pointing System. Prior to SL-2, the first operational Spacelab mission, SL-3, will be flown. It will be another flight of a manned module. This mission is scheduled for launch in early 1985. Delivery of the second Spacelab module and the second igloo will also take place in FY 1984.

Engineering and Technical Base

Requested funding of $93.1 million in FY 1984 for the Engineering and Technical Base provides the minimal (core) capability to sustain an engineering and development base to support STS systems at JSC, KSC, MSFC and NSTL. It also provides necessary equipment and supplies and to perform alternative design, testing, and analyses in high technology areas of design and development. This core capability provides for a five day, one shift operation at designated institutional research and development facilities at the designated OSF installations. The budget estimates for other NASA programs includes funding for the additional support.

Payload Operations and Support Equipment

The Payload Operations and Support Equipment Program provides payload services which are required over and above standard Shuttle services. Payload operations provides unique hardware analysis and launch site services to support STS missions. Payload support equipment provides for development and acquisition of reuseable ground support equipment.

The funding being requested for FY 1984 is needed to continue payload operations. The FY 1984 funding request of $53.2 million is required to continue support of these functions: The NASA portion of the mission costs for the retrieval and repair of the Solar Maximum Mission Spacecraft (jointly funded by the DOD), Galileo, ISPM, TDRSS, Space Telescope and Spacelabs 2 and 3. The funding will also support operations and maintenance of the Payload Operations Control Center (POCC).

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Satellite servicing has always been planned as an important feature of the STS. Toward that end, we are now planning to perform an experimental demonstration of the refueling process in the Space Shuttle Bay, perhaps as soon as STS-11. In this demonstration, an astronaut will fuel a simulated satellite through the same valves that were used to fuel it on the ground. This is a first step in developing orbital servicing as an option for future satellites.

Advanced Programs

During FY 1983, the Advanced Programs efforts are focused on system and subsystem studies and advanced development for the continued definition of free-flying and tethered space platforms to operate with the Shuttle as well as for potential use with a Space Station; the investigation of systems, tools, and techniques for placement, retrieval, and maintenance/repairs of spacecraft; the definition of advanced transportation vehicle concepts including orbital transfer vehicles and Shuttle-derived vehicles; and the initial mission analyses and planning for a Space Station.

In FY 1984, we are requesting $15 million for Advanced Programs to provide continued efforts on a variety of preliminary concept studies and advanced development of some key items. It also allows for continued efforts on Space Station analysis with the primary focus being the initiation of in-house system definition activity and some advanced development work. This is a result of the activities carried out during FY 1983. Major systems options under preliminary concept study fall into three categories: platforms and facilities in both low-Earth orbit and geosynchronous orbit, orbital services such as satellite servicing, and advanced transportation.

Included in the budget request is $3.3 million for initiation of development on the Tethered Satellite System (TSS), a cooperative effort with the Italian Government. This program will develop and flight test a deploying system for tethering a payload to distances of 100 km below or above the orbiter, and a scientific experiment package to utilize this capability. Italy will develop the satellite for accommodating the experiments.

SPACE TRANSPORTATION OPERATIONS

Space Transportation Operations provides the standard operational support services for both of the primary U.S. space launch systems: the Space Shuttle and the expendable launch vehicles. Within STS operations, ET and SRB flight hardware is produced; operational spare hardware is provisioned, overhauled and repaired; and the manpower, propellants, and other materials are furnished to conduct and support both launch and landing operations. The Space Transportation Operations program provides for the launch of NASA, DOD, other U.S. Government, domestic commercial and international missions.

Our FY 1984 budget request for Space Transportation Operations is $1,570.6 million which represents an increase of 8% or $116.9 million over the current FY 1983 estimate.

Shuttle Operations

Shuttle Operations has three principal areas: flight operations, flight hardware and launch and landing operataions. The FY 1984 funding request for flight operations is primarily for manpower to sustain the maintenance and operation of the onboard avionics software and mission control system, the maintenance and operations of the aircraft and simulators for flight crew training, the analysis and generation of mission planning, the conduct and control of the STS misssions, and the training of the flight controllers at the JSC. The funding request also covers manpower for the integration engineering required to coordinate all flight elements and to assure systems safety and integrity, the planning to assure compatibility and verification of payload interfaces, the support of crew operations and training programs, and program support at JSC and NASA Headquarters. Also included in the request are funds for the operation and maintenance of the Shuttle Avionics Integration Laboratory (SAIL), which is utilized to test and verify the ongoing operations software and hardware modifications.

Within the flight hardware line, operational spare hardware is provisioned, overhauled and repaired and the propellants and other materials are furnished to conduct and support both launch and landing operations. Orbiter and flight spares and crew equipment spares are based on calculations involving flight rates, maintenance schedules, operational hours, turnaround time and lead time to procure spares.

The FY 1984 funding request for launch and landing operations is for manpower to process and integrate the Orbiter, ET, SRB and the SSME into the proper launch configuration preparatory to each flight and process and prepare the payloads into the orbiter vehicle. Support manpower is also included to conduct the SRB retrieval operations, configuration control, transportation, logistics, inventory control and program support at KSC. Procurement and maintenance of replacement ground support equipment (GSE) and spares used in the conduct of ground operation is also included. In addition, propellants for base support and launch operations--excluding the SRB propellants--are procured under this category. Landing support at Dryden and for contingency landing sites is included in addition to that furnished for Kennedy Space Center landings.

The funding request for launch and landing in FY 1984 takes into account the initial costs and projected manpower savings for implementation of the Shuttle processing contract and base operations contract. The transition from the current multiple contractor operation to consolidated contracts for Shuttle launch operations and base operations is specifically intended to achieve economical launch and landing processing.

We are requesting $50 million in FY 1984 for expendable launch vehicles to provide for centralized procurement and launch services for NASA's automated spacecraft missions as well as other agencies' and organizations' requirements. The expendable launch vehicles are the Scout, Atlas Centaur, Delta and Atlas-F. In FY 1984, only the Delta requires appropriated funding in that the other vehicle systems are provided to users on a fully reimbursable basis.

Mr. Chairman, this completes my prepared testimony. In summary, I would like to underscore that the STS is well into its initial operational phase, and our success to date rests strongly on the individual efforts of thousands of Americans who are continuing to demonstrate that this country, our people, and our economic system is equal to the challenge of the space age. Furthermore, your vision and the Congress' continuing support of this vital program is providing all of us an achievement that this nation and the world has taken to its heart....and we are both proud and privileged to be a part of this great undertaking.

QUESTION 1:

Could you elaborate on the most recent report of the Aerospace Safety Advisory Panel related to the Space Shuttle? Are you aware of any unresolved safety issues concerning the Space Shuttle?

ANSWER 1:

The Panel's most recent annual report was presented to the NASA Administrator on February 8, 1983, covering its activities for the calendar year 1982. The Panel reported upon various facets of the Space Shuttle program and on aircraft flight safety. With respect to the Shuttle they made the following recommendations:

- A formal program should be implemented to identify flight test objectives compatible with each new Shuttle mission so that the entire flight envelope will be defined in a timely manner.

- Extreme caution should be used when decreasing structural safety facets for weight reduction purposes until all pertinent data are explored; as a corollary, appropriate instrumentation packages should be carried until flight limits are determined.

- NASA should identify a single, responsible operational logistics group, properly staffed, to assess logistics methodology to be followed.

- During the operational period, the sustaining engineering should be the responsibility of the operational organization.

- Current and future changes in the Shuttle must have the same rigor of hardware/software certification as in the past. Such policy and standards should be established by an independent group, e.g., NASA's Chief Engineer, and should have the direct sponsorship of the NASA Administrator.

- Autoland of the orbiter should be tried at the earliest opportunity where there is a "repeat" pilot who has made a previous manual orbiter landing.

- New turbomachinery for the main engine should be designed to achieve current mission life at the full power level.

- A gear redesign study should be initiated to achieve an adequate factor of safety with the maximum proposed Shuttle loads.

The ASAP identifies crew survivability as a principal continuing concern should a ground or low altitude mishap occur and urges continued analyses of potential systems to safeguard the crews. In addition, in the Panel's judgment, the following areas are also of concern:

- Auxiliary Propulsion Units in both the orbiter and the solid rocket booster.

- Rudder-speed-brake control system downstream of the drive motors.

- The landing system, particularly the wheels and tires.

- Extravehicular Activity Systems

We share the ASAP concern in these areas and are studying approaches to mitigate these recognized program risks.

QUESTION 2:

NASA has again included funds for Changes and Systems Upgrading activities:

a. Is this funding still considered to be program reserves?

b. Why does the FY 1984 request exceed the current estimate for FY 1983?

c. Is this funding still controlled by the Administrator?

ANSWER 2:

a. The Changes and Systems Upgrading budget represents an allowance or reserve for potential changes and systems modifications and unanticipated developments not provided for in the program element budget estimates. This funding allowance is to provide for those programmatic and technical changes which will improve reliability, increase operating efficiency and/or reduce costs.

b. The estimate for Changes and Systems Upgrading included in the FY 1983 budget request was $72.5 million. The current FY 1983 estimate is $25.0 million as a result of the reallocation of $37.5 million to Shuttle production and capability development program elements and a $10.0 million reduction as part of the Agency's response to the general reduction made by the Congress in NASA's FY 1983 appropriation for R&D activities. The reallocation to Shuttle production and capability development was to provide for program changes such as: initiation of work on the third mobile launcher platform the addition of a fifth cryogenic tank to extend the first Spacelab on-orbit time; long lead main engine hardware and critical components to replace hardware lost during engine test incidents and the initiation of a new engine controller development.

c. As a part of the Agency's budget formulation process, candidate requirements for reallocation of the Changes and Systems Upgrading budget are reviewed with the NASA Administrator.

QUESTION 3:

Budget projections for Space Transportation Systems activities have increased significantly in the past year.

a. Could you elaborate on the need for increased resource requirements of $1.2 billion for the Space Transportation System through FY 1987?

b. What is being done to improve resource requirements projections?

c. Are the program reserves being budgeted in FY 1984 commensurate with program schedule and technical risk?

ANSWER 3:

a. The $1.2 billion increase in Space Transporation System activities represents the total difference between the runout of the FY 1983 and FY 1984 budget estimates, in equivalent real year dollars, for the years FY 1983 through FY 1987. This net increase to the runout of the FY 1983 budget is primarily the result of new program content and necessary adjustments based on the experience acquired in the first five STS missions.

The majority, approximately $725 million, of this total increase is in the Shuttle Production and Capability Development program elements. The major changes include: $400 million for orbiter structural spares; $167 million for Centaur modifications to the Shuttle orbiter and launch facilities plus acceleration of PAD-B; $52 million for interim modifications to Columbia for the first Spacelab flight and the deferral of the full-up modification to FY 1985; $93 million for JSC mission support requirements including the third Shuttle training aircraft (STA) plus STA rewinging and data system equipment replacement; $47 million for a third mobile launcher platform (MLP); $37 million for revised orbiter initial spares requirements; $80 million for increased external tank residual development and tooling requirements; $67 million for orbital flight test (OFT) flight damage repair and design improvements for the solid rocket boosters (SRB); and $175 million for revised main engine confidence testing activities and reallocation of anomaly resolution testing reallocated from Shuttle Operations.

These increases were offset somewhat by reductions in the Shuttle Production and Capability Development budget runout, including revised estimates for the filament wound case (FWC) development (-$57 million), a reduction in the Changes and Systems Upgrading estimates (-$272 million), and the net effect of numerous other program adjustments (-$64 million).

The remaining increase of approximately $460 million for program elements other than those in the Shuttle Production and Capability Development budget includes: $41 million for the NASA share of the joint development of a tether satellite system; $79 million for Delta launch vehicle procurement and support; a reduction of $40 million in the advanced engine technology development planning wedge; $97 million net increase for baselining the Centaur upper stage development operations (rather than Inertial Upper Stage (IUS)) for planetary missions and the cancellation, the IUS vehicles for TDRS-E and TDRS-F; the addition of $32 million for the Centaur launch of the Venus Radar Mapper in 1988; an increase of approximately $198 million in Shuttle Operations or about 2.5 percent of the aggregate total over the 5-year period, primarily for external tank and solid rocket booster hardware and revised flight operations requirements; and, $47 million for increased Spacelab Operations manpower and spares.

b. Our budget planning has had to be responsive to the experience of past years. There have been specific program adjustments necessitated by the STS flight experience to date and unforeseen main engine testing difficulties. We have increased the

involvement of the center project personnel in the budget process. It is intended to continue to emphasize this approach with the objective of further improving our requirements forecasting.

c. The allowance for reserves in the Shuttle Production and Capability and Shuttle Operations budget for FY 1984 was based on our assessment of known schedule and technical risks at the time the budget was formulated in 1982. Since that time, we have encountered a number of problems with the Space Shuttle Main Engine program which are under assessment in terms of their impact on future program requirements. Reallocation of the total reserves among the various elements of the program will, in all likelihood, be necessary as we progress into FY 1984.

QUESTION 4:

Does the FY 1984 budget request fully support the facilities and tooling necessary to achieve 24 flights per year for all elements of the Shuttle program?

ANSWER 4:

The FY 1984 CoF budget request will provide a basic capability to achieve a planned flight rate of 24 missions per year. NASA is also evaluating various options for an alternate plan for SRB refurbishment/processing recompetition and operations for more effective long-range efficiencies. Depending on the final option selected, various courses of funding or implementation are being considered.

In the FY 1984 R&D funding request, an appropriate amount of resources are included to support achievement of the 24 flights per year capability in the 1988 time frame. Additional R&D investments required to complete the establishment of the 24 per year capability are included as required in the FY 1984 budget runout projections.

QUESTION 5:

A recent Aviation Week article reported that combining DOD and NASA Shuttle facility and operations costs into a separate entity is under initial evaluation at NASA.

a. What would be the objective of such an action?

b. Would not such an action increase the budget threat to the Space Science and Applications program?

ANSWER 5:

a. Since its inception in 1972, the STS program has been a partnership between the NASA and the DOD with each agency providing both investment and program funding through their respective budgets. As the STS program finishes initial development and transitions to an operational capability, even closer coordination of the two separate STS budgets is required to (1) insure programs are funded and accomplished in a timely fashion, (2) insure timely operation of a two coast launch capability and (3) promote efficiencies of NASA and DOD STS facilities, equipment and

manpower. Closer coordination is presently being implemented through a joint NASA and DOD STS program/budget review. We are actively considering options to promote improved budget planning and coordination of the NASA and DOD program budgets for the STS program.

b. The Space Science and Applications and other R&D funding requests are considered individually and presented for review by the Administration and Congress. Better planning and integration of the NASA/DOD STS budgets should not pose any threat to these budget items.

QUESTION 6:

Could you elaborate on what NASA is doing to increase productivity with regard to contract incentives?

ANSWER 6:

In addition to implementing fixed-price incentive contract provisions for a number of the hardware element contracts, more manpower-intensive Space Shuttle operations contracts are being consolidated and incentivized to increase productivity. The first of these consolidations occurred January 1, 1983, when EG&G became the KSC base operations contractor (BOC) replacing 14 separate contracts. Experience to date with the BOC indicates the future cost savings due to increased productivity could be on the order of 20 percent. The next major consolidation will occur at KSC this fall when the Shuttle processing contractor (SPC) is selected to replace the existing element contractors. The SPC will also be an incentive contract, and we expect the savings to be substantial, based on the BOC experiences. Implementation of an incentivized contract at KSC for cargo processing is under review, as is the possible consolidation of several operations contracts at JSC supporting the Space Shuttle program.

QUESTION 7:

Does NASA plan to transition to a larger share of fixed price contracting for the Shuttle production and operations activities?

ANSWER 7:

As new procurements are initiated or existing contract options are up for renewal, NASA evaluates alternative contacting modes against such factors as system maturity, anticipated changes, and technical complexity. Decisions on the method of contracting are based upon the best interests of the Government and are made on a case-by-case basis. As the STS matures, NASA anticipates being able to utilize a larger percentage of fixed price incentivized contracts, which should result in significant savings over previous contracting methods.

QUESTION 8:

Has NASA planning increased private sector involvement in Shuttle marketing activities?

a. If not, why not? What concepts are being considered?

b. What is the advantage of increased private sector involvement in Shuttle marketing? What are the disadvantages?

ANSWER 8:

a. Yes, NASA is considering increased private sector involvement in Shuttle marketing activities. The first step in this direction was taken by the NASA Administrator. Through the NASA Advisory Council, a Task Force on the Effective Utilization of the Shuttle has been formed. Its members are outstanding experts from the private sector. The purpose of this group is to determine how NASA can make best use of the Shuttle. The scope of this effort will encompass a broad spectrum of possible concepts applicable to near term and further out in time. In view of the major national investment in this program, we consider this to be an extremely high priority effort.

b. In our judgment, involvement of the private sector should be advantageous, and within the next few months, we expect that several new and specific approaches as to how it can best be achieved will be defined.

QUESTION 9:

We understand that DOD has reduced or cancelled Shuttle payloads in FY 1984 and 1985. What is the impact on NASA reimbursable funding in FY 1983 and 1984? Did NASA increase its budget request because of this reduction in projected reimbursable funding?

ANSWER 9:

The FY 1983 payment by the Air Force is being maintained at the level previously planned, even though the Air Force plans to fly only one flight in FY 1984 instead of the two flights previously planned. The change in the number of FY 1985 flights was recognized in the budget formulation process for NASA. It should be noted that the recently signed NASA/Air Force Memorandum of Agreement (MOA) on Reimbursement of Launch and Associated Services establishes the principle of a rolling three year fixed payment schedule for DOD launches. With this MOA, stability is provided to both NASA and the Air Force in their respective budget projections. Thus, the need for corresponding increases or decreases in the NASA and Air Force budget requests is eliminated. More specifically, with this MOA the DOD reimbursements to NASA in FY 1983 through FY 1985 are fixed. However, consistent with the concept of a rolling fixed three year payment schedule, reimbursement adjustments needed for any payload changes (increases or reductions) within the FY 1983 through FY 1985 period will be reflected in the FY 1986 projection.

NASA did not have to increase its budget due to the change in the Air Force launch plans.

QUESTION 10:

The House/Senate Conference Report on the FY 1983 authorization included authorization of funding for orbiter vehicle 105.

a. What amount of FY 1983 funding is being devoted to long lead procurement of spares that could be used for OV-105, if production of OV-105 were approved?

b. What is the total FY 1983 funding available for orbiter spares?

ANSWER 10:

a. The FY 1984 budget request includes provision for approximately $20 million in FY 1983 to be applied to the orbiter structural spares program.

b. The FY 1983 Operating Plan provides $95 million for initial lay-in spares, $20 million for the structural spares, and $38 million for replenishment spares in FY 1983-- a total of $153 million.

QUESTION 11:

Does the FY 1984 budget request fully support the planned delivery schedule of September, 1983 for OV-103 and December, 1984 for OV-104? Does the contractor agree with the Agency assessment?

ANSWER 11:

There have been no changes in the delivery dates of the remaining production orbiters since last year's hearing. The planned modification period to bring OV-102 to its full operational capability has been delayed to FY 1985. However, pending the results from the experience of operating two differently configured orbiters, NASA retains the option of moving this modification forward into FY 1984. In that unlikely event, the schedule for completing OV-104 would in all likelihood be delayed. Delivery dates consistent with the FY 1984 budget are as follows:

OV-103 - September 1983

OV-104 - December 1984

Yes, the contractor's assessment is consistent with that of the Agency's.

QUESTION 12:

In an August 1982 letter from NASA to the Congress, the NASA Administrator noted that the Air Force would transfer funds to NASA for the purchase of orbiter spares after the successful completion of the sixth Shuttle mission. Is this commitment still available? What amount of funds will be transferred from the Air Force?

ANSWER 12:

The Department of Defense has no money explicitly identified for orbiter spares. Under both the prior and the recently renegotiated agreements between NASA and the DOD for Shuttle flight charge reimbursement, orbiter spares are a NASA funding responsibility and flight replacement spares are an element of cost included in the reimbursable charge per flight.

QUESTION 13:

The FY 1984 budget request includes funds for orbiter structural spares.

a. How much funding did NASA request from OMB for OV-105?

b. Of this amount how much is included in FY 1984 for orbiter spares?

c. How long will the FY 1984 funding for orbiter spares maintain an option for OV-105?

d. If Congress added another $100 million for OV-105 in FY 1984 what would be an efficient delivery schedule and total production cost of OV-105?

e. If the OV-105 decision is delayed to FY 1985, what would be the delivery schedule and total production cost of OV-105?

f. What funding level would be required in FY 1984 to maintain the most efficient production schedule?

ANSWER 13:

a. NASA requested $200 million in FY 1984 for a FY 1984 OV-105 new start with a runout cost of $1.8 billion (RY$) for a later 1988 delivery.

b. The FY 1984 budget request includes $100 million in FY 1984 for orbital structural spares.

c. The FY 1984 orbiter structural spares program will effectively maintain a production capability for OV-105 through FY 1985.

d. The total cost would be on the order of $1.8 billion, based on a late 1988-early 1989 delivery schedule.

e. If the Congress approves the $100 million structural spares program in FY 1984 and was given full authority to proceed with OV-105 start in FY 1985, an efficient delivery schedule would be a mid 1989 delivery with an estimated runout cost of approximately $1.9 billion in real year dollars.

f. At the time the FY 1984 budget was formulated, it was estimated that an effective production schedule could be achieved at a funding level of $200 million in FY 1984. It was recognized at that time that most efficient production schedule would have required nearly $400 million in FY 1984 and additional funding in FY 1983.

QUESTION 14:

In the previous two years, the Committee has requested a review by NASA and the Air Force of the need for additional orbiters looking towards the possibility of a block purchase.

a. What is the status of that review?

b. When will this review be formally submitted to the Committee?

ANSWER 14:

a. A draft of this study was completed by NASA in the early fall of 1982. This study covered aspects relating to a decision on procuring additional orbiters under various options. Although the Committee had requested that the study be undertaken in conjunction with the Department of Defense, the study represented only the inputs of NASA.

b. The draft was reviewed by the Administration in the process of formulating the FY 1984 budget. The Administration believed that the study required the incorporation of the most recent projections of firm commercial, foreign, DOD and NASA flights. NASA agreed to delay finalization of the study until after a comprehensive review of all the factors pertaining to the need for additional orbiters could be completed under the direction of the Senior Interagency Group. At the request of Congress, a revised version of the study is being prepared which incorporates the latest data available. This will be submitted to the Congress as soon as the updated information can be incorporated.

QUESTION 15:

In response to a question for the record last year, NASA stated that the Agency was proceeding with a study effort with Rockwell International, designed to look at the possibilities, benefits, trade-offs, etc., of implementing a block buy of OV-105. NASA further stated that this study would be made available to the Committee.

a. When was the study completed?

b. Why has this study not been submitted to the Committee?

ANSWER 15:

This data was a part of the study cited above in the answer to question 14.

QUESTION 16:

a. What is the status of NASA's review of the Space Transportation Company's proposal to the Government regarding private sector financing of a fifth orbiter?

b. Is the proposal complete or does it lack critical components?

c. Could you elaborate on the Agency's view on this proposal?

d. Is such a concept an appropriate Government/private sector endeavor?

ANSWER 16:

a. NASA has held a series of discussions with the Space Transportation Company with an objective of exploring and gaining a better understanding of the concept proposed. The Space Transportation Company has indicated that, on the basis of these discussions and the FY 1984 budget, it is preparing a revised and more complete submission to NASA.

b. The information provided to NASA was not a complete proposal. The Space Transportation Company also indicated that the terms and conditions submitted and defined the concepts defined were to be considered negotiable. The information provided to NASA was sufficient to perform only a preliminary evaluation of certain aspects of the concept.

c. Since the Space Transportation Company has informed NASA that it is in the process of preparing a more complete and definitive proposal, it would be premature to discuss the specifics of NASA's views prior to a thorough evaluation of this more comprehensive submission. NASA feels that, in concept, the proposal was consistent with the objective of expanded private sector involvement and investment in the conduct of space activities. Nevertheless, there were areas in the submittal that would, in our opinion, require modification to meet the criteria of being in the public interest as well as meeting the legitimate needs of the Space Transporation Company.

d. NASA feels that there are benefits to both the Government and the private sector which can be derived from such endeavors. NASA is also aware that it must carefully evaluate both the potential benefits and the problems for both sectors in the process of making a determination on the merits of each specific proposal. Concepts such as this one are, in principal, consistent with the national policy of increasing private sector involvement and investment in space activities.

QUESTION 17:

Please provide for the record the production orbiter funding by fiscal year and by orbiter vehicle. What is the level of change orders being experienced on the orbiter production contract? Is this level of change order activity excessive?

ANSWER 17:

The following vehicle break is in constant FY 1984 dollars:

	PRIOR	FY 82	FY 83	FY 84	FY 85	TOTAL
099	972	183	13	1	---	1169
102 Modification	72	64	49	12	47	244
103	476	344	284	33	---	1137
104	163	242	375	378	119	1277

Change orders are running at a rate of approximately 16 per month. This represents a reduction over the number experienced over the last year. The rate of "normal" change traffic is actually less because

two major programmatic changes are reflected in the 16 per month figure. The decision to incorporate Centaur on vehicles OV-099 and OV-104 plus the decision to modify OV-102 for the Spacelab only modification have together made up nearly a third of the total value of changes in the past 12 months.

NASA does not believe the number is excessive at this stage of the program. Only five flights have been conducted and changes are expected in the early flight stages as problems occur and fixes and improvements are identified. However, we are alert to the cost impact of changes and have put in place management procedures designed to make certain that only high priority and mandatory changes are approved.

QUESTION 18:

What is the status of the new thermal protection system for production orbiters?

ANSWER 18:

FRCI-12 is an advanced tile being used in lieu of LI-2200 tile on OV-103 and subsequent vehicles. Its use will save approximately 1000 pounds weight per vehicle. For OV-103, tile delivery is nearly complete and installation is about sixty percent complete. Certification testing is completed for the most part. The remaining testing is to verify multimission reusability of the tile.

AFRSI is an advanced flexibile reusable surface insulation being used in lieu of the LRSI white tile and part of the FRSI on OV-103 and subsequent. A portion of the Orbital Maneuvering System pod on OV-099 has been covered with AFRSI for an early demonstration. AFRSI reduces the manufacturing and maintenance efforts compared to LRSI tile and has a higher temperature capability than FRSI.

During the last part of 1982, delivery problems were encountered with the AFRSI. However, this situation has been corrected and most of the AFRSI is now delivered for OV-103. With the improved delivery situation, the installation rate is increasing satisfactorily with approximately 380 of a planned 2276 AFRSI blankets presently installed.

QUESTION 19:

Could you elaborate on the history of the orbiter fleet size requirements? What was the original fleet size projection?

ANSWER 19:

Original planning at the time of program approval in 1972 envisioned a five orbiter fleet supporting a projected mission model of 572 flights over a 12 year period. This five orbiter fleet was to be made up of two design, development, test & evaluation vehicles and three production vehicles.

During the course of the FY 1977 budget preparations, both OMB and NASA reviewed the mission model size and fleet size requirements. This review concluded that five orbiters were necessary; however, due to budget constraints, the procurements were stretched out.

In 1977 and 1978, this issue was again studied by the Carter Administration and the FY 1979 budget contained funds for four orbiters with procurement of the fifth orbiter being deferred.

Congress, in its FY 1979 budget deliberations, decided the fifth orbiter option should be kept open and added $4 million for fifth orbiter long lead items.

The FY 1980 NASA budget request to the Administration contained funds for a fifth orbiter. These funds were subsequently deleted after program was reviewed within the Administration. The requirement for a fifth orbiter was also reviewed in the FY 1981 through FY 1983 budget requests; funding for a fifth orbiter was not included in those years' budget recommendations.

Currently, the authorized fleet size remains at four. The FY 1984 budget request contains funds for orbiter structural spares. The procurement of these spares will retain the capability to produce a fifth orbiter, if such a decision is made at a later date.

QUESTION 20:

a. With a limited orbiter fleet what are the chances that launch priority afforded defense and national security payloads will preempt civil government and commercial payloads?

b. With a four-orbiter fleet can NASA guarantee launch availability for civil government and commercial payloads?

c. Does uncertainty in Shuttle orbiter launch rate capacity in concert with national security payload priority strengthen the competitive posture of foreign launch vehicle systems?

d. Will delays in production of a fifth orbiter increase the procurement cost? How much?

ANSWER 20:

a. Many of the most important DOD missions are launched from the Western Launch Site (WLS) where the scheduling for Shuttle launches will be less crowded for the foreseeable future. Nevertheless, the potential for DOD preemptive missions is a low probability at either the Western or Eastern Launch Sites because the DOD requests for flight assignments are, for the most part, based on predictable requirements. In some circumstances, such as replenishment missions, call-up launches could be required, but even these require extended planning periods of 6 months or more. Therefore, unscheduled launches should be able to be handled within the flexibility of the overall reservations set aside for DOD missions. Preemptive missions, impacting civil government or commercial payloads, are considered to be a low probability.

b. Barring any accidental loss or major damage to one of the orbiters, this Administration believes a four-orbiter fleet should be adequate through at least the end of the decade.

c. We believe that Shuttle launch rate capacity is adequate to meet the projected demand through at least the 1980's. As a result, we do not believe this should be a concern to potential customers. National security payloads would appear not to be a significant factor.

d. Yes. The amount is uncertain, depending upon the timing of the decision to proceed. The effects of inflation would be an element of the increase in procurement costs. However, the procurement of structural spares is anticipated to significantly mitigate the extent of the increase in costs.

QUESTION 21:

It has come to our attention that the NASA mission model is decreasing as we get closer to hard user commitments. (Specifically, the Air Force requirements.) Is this a true statement?

ANSWER 21:

The statement is not entirely correct. While it is true that the NASA mission model (which does not necessarily reflect "demand") was decreasing prior to the first Space Shuttle mission (STS-1) on April 12, 1981, since then the mission model has remained very stable. Over these last two years, we have maintained a stable and realistic plan for up to 31 to 32 flights through FY 1985 inspite of some decreases in planned DOD flights with a planned steady growth to a capability of 24 flights per year by FY 1988.

The outstanding success demonstrated in the first five Space Shuttle flights has served to encourage more firm participation in the program. More specifically, the number of paid reservations, signed launch service agreements, joint endeavors, and number of customers making progress payments has, since April 12, 1981, increased significantly. It is reasonable to expect this trend to continue as additional successful Shuttle missions are completed and as launch agreements are usually made and payments begun about three years prior to launch.

QUESTION 22:

Have you looked at some forms of charge or penalty against the user for deferring or cancelling their mission?

ANSWER 22:

Yes, we have looked at these types of charges and have incorporated the concept of penalties into the Shuttle Reimbursement Policy. For example, while a customer may postpone a payload one time with no penalty (if postponements occurs more than one year before launch), subsequent postponements cost a customer a fee of five percent of his flight price. For a postponement requested one year or less before a mission, the penalty is five percent plus an occupancy fee according to the following schedule:

Fifty percent if postponement is requested more than six months but less than one year before flight.

Ninety percent if postponement is requested six months or less before the scheduled mission.

Should a customer cancel more than a year before the scheduled launch, a ten percent penalty is charged. The fee charged for a cancellation one year or less before launch is ten percent plus the occupancy fee just described.

QUESTION 23:

Could you describe the cause of the main engine leaks which have occurred recently?

ANSWER 23:

There were three separate leaks discovered on the Challenger engines. The leak in the main chamber coolant discharge manifold resulted from a crack caused by hydrogen environment embrittlement. The root cause was excessively high residual stress, resulting from a one-of-a-kind repair, not anticipated by engineering. The heat exchanger leak resulted from a crack in a weld initiating from a weld defect. The leak in the augmented spark ignitor fuel feedline resulted from braze penetration through the line due to overheating during brazing.

QUESTION 24:

As a result of the recent experience at the launch pad, is NASA changing test and operational procedures to avoid these launch delays in the future?

a. What is the current situtation regarding availability of engine spares and spare engine parts from Columbia and Challenger?

b. Does the engine production schedule fully support the orbiter delivery schedule?

ANSWER 24:

NASA is developing improved leak testing techniques to be applied to engines both during and after acceptance testing. These should preclude delivery of an engine with leaks that could cause launch delays. In addition, an operational leak isolation test has been developed for use on the vehicle to better measure leakage which develops between flights.

a. As far as spares and spare components are concerned, supplies are quite limited at the present time. Only one dedicated spare engine is presently available, i.e., one of the original Columbia engines. However, the program will "juggle" engines destined for OV-102 and OV-103 to provide spares backup for OV-099 for a period of nearly a year. This is a very unsatisfactory arrangement, but temporarily necessary. A new, dedicated spare will

be available in FY 1984. We are currently reassessing our spares position and will augment spares where possible in the near term, and adjust the program to improve the spares position in the future.

b. The engine production schedule support orbiter delivery schedules.

QUESTION 25:

The Aerospace Safety Advisory Panel recently recommended that NASA plan for more engine parts, as well as development of a dedicated facility for maintenance and overhaul.

a. Could you comment on this recommendation?

b. Do you believe that your current plans include adequate engine spares?

ANSWER 25:

a. A dedicated overhaul facility has been established, within the Rocketdyne plant, for maintenance and overhaul activities. This facility will serve as a focal point for disassembly, inspection and reassembly operations on recycled components and engines.

b. Spares planning is being reassessed in light of our recent operational problems. We will make the necessary program adjustments to improve our operational support posture when these reassessments are completed.

QUESTION 26:

Are there any production gaps in the main engine program?

a. When is full power level engine certification planned for completion?

b. What is the current status?

c. Does the current schedule satisfy mission requirements?

d. Are there adequate reserves to cover unforeseen problems or test failures?

ANSWER 26:

There are presently no production gaps in the main engine program. These were smoothed out during replanning and rebudgeting exercises during FY 1982 and FY 1983.

a. The full power level certification was scheduled for completion in early calendar year 1983. However, this date is being reassessed. Specific certification testing will proceed on schedule, which puts first priority on flight engine spare support through 1983. The program requirement for 109 percent engine capability is October 1985.

b. To date, three of the four certification cycles have been completed. Only four (of thirteen) tests remain to complete the fourth required cycle. The schedule for a full main engine propulsion test (firing all three engines together at 109 percent) is being delayed.

c. This certification schedule fully satisfies mission requirements through October 1985. At that time, higher power levels will be required for some heavyweight polar orbit missions.

d. Spares and reserves to support this, and the follow-up flight certification extension testing, are minimal and are being reassessed.

QUESTION 27:

On the new engine that is being delivered to the Cape for the next STS launch--it apparently has undergone very detailed tests at another facility, namely, NSTL.

a. Since NSTL did not find any leaks on the previous engines before shipping them to the Cape, what is your confidence factor on these engines having no internal leaks?

b. Do you have any intention of performing any additional leak checks when they arrive in Florida?

c. Are you going to perform another Flight Readiness Firing (FRF) before the flight?

ANSWER 27:

a. As a result of our recent leak test problems, a special whole engine leak test has been developed. This was applied to the replacement engine after acceptance test at NSTL. With the results of this test, we are highly confident that no significant leaks exist in this engine.

b. At KSC, the routine, post-installation leak tests will be performed, and a special aft compartment leak isolation test will be performed after all engines are reinstalled.

c. These tests will make another Flight Readiness Firing unnecessary.

QUESTION 28:

Has the basic oxygen leak issue in the heat exchanger been submitted to the Aerospace Safety Advisory Panel for review or do you feel that you have sufficient information that the data shows no generic design problem?

ANSWER 28:

The Aerospace Safety Advisory Panel has been advised of, and has participated in, several telecons addressing the heat exchanger leak. Data on the processing of the heat exchanger indicate that the leak was due to a weld defect, not detected during fabrication.

Special tests have been devised and applied to Challenger engines to assure that similar defects do not exist in these engines. Several improvements were incorporated in the heat exchanger processing in 1977 and 1980, to improve inspection of welds and to improve the welding process. Unfortunately, these actions were implemented too late to catch the problem on engine 2016. All current flight engines will have heat exchangers with the improved processing.

QUESTION 29:

Do you feel there are sufficient checks and balances of your testing approach not only of the main engine, but also the total Shuttle system between the various facilities and sufficient communications to avoid future major tactical delays in the program?

ANSWER 29:

The fact that our routine testing (Flight Readiness Firing) of a new Shuttle vehicle detected the engine problems on the ground attests to the validity of our checks and balances for the overall Shuttle system. However, these engine problems did point out deficiencies in our subsystem testing. Improved techniques have now been developed for engine leak detection, early in subsystems test, to avoid the schedule impacts, such as occurred on Challenger. In addition, we are reevaluating our current techniques for other subsystems as a result of this late discovery on engines. A panel is being assembled with representatives from each Shuttle contractor and each NASA center to conduct this reevaluation to assure that all lessons learned will be communicated throughout the Shuttle community.

QUESTION 30:

a. What is the status of activities related to the Shuttle Processing Contract at Kennedy Space Center?

b. What are the near term and long term cost impacts?

c. What are the schedule and program risks associated with transition to a Shuttle Processing Contractor?

ANSWER 30:

a. The request for proposals (RFP) for the Shuttle Processing Contract was formally released to industry on January 19, 1983. The RFP covers Shuttle processing at both the KSC and VAFB. Proposals are due on April 29, 1983; contractor selection is expected about August 15, 1983, and the contractor is expected to start work about September 15, 1983.

b. Cost savings of approximately 20 percent over previous modes of contracting are anticipated.

c. No schedule or program risks are expected with transition to a Shuttle Processing Contract. We have, during the past year and a half, had many discussions with the Shuttle development contractors and with other contractors interested in the competition. These discussions have led to a broad acceptance of the concept of transition by criteria at KSC and of transition by schedule at

Vandenberg Air Force Base (VAFB). The RFP illustrates the type of criteria which will be applied but invites the proposers to recommend their own concept of the transition process using multi-party formal agreements between the SPC, the incumbent(s) and the Government, administrative agreements and schedules related to personnel transfers, training agreements, accountability transfers, completion of processing policies, plans and implementing instructions, completion of accountability or inventory transfers, and SPC-to-development contractor interface agreements on design liaison. We believe that participation of the selected contractor in establishing the final plan for transition is essential because that plan will be significantly affected by the workforce which it brings to the job. NASA is fully aware of the significance which must be placed on satisfactory demonstration of the competence of the contractor to assure responsibility for Shuttle processing prior to the shift of this responsibility. We shall very carefully examine the specific transition criteria and the measure of contractor competence as the transition evolves.

QUESTION 31:

a. What is the unit cost impact of the lightweight design?

b. The Aerospace Safety Advisory Panel has raised concerns regarding the safety margin of the lightweight tank design. Would you comment?

ANSWER 31:

a. The lightweight design unit cost impact has been established as approximately one million dollars per tank.

b. Potential buckling at the orbiter aft attach point following SRB separation was investigated by the panel. After a thorough review with NASA, contractor, and expert consultants, it was agreed that sufficient safety margins existed for SSME power levels up to 104 percent. It was also agreed that additional analysis would be required for SSME power levels greater than 104 percent. The results of this analysis will be reviewed by all concerned to verify that proper safety margins exist for the higher SSME power levels.

QUESTION 32:

a. Could you elaborate on the major efforts underway to reduce the production costs and schedule for the external tank?

b. What are the projected unit cost savings?

ANSWER 32:

a. The external tank project is contributing to the Space Shuttle program goal of reducing cost through its Producibility Program. The producibility program's purpose is to reduce operating costs by introducing efficiencies into the production for external tanks. The goal of the program is to save $66 million on the first 54 production tanks. To date, more than 80 items have been approved or are pending approval for a projected savings of $61 million through tank number 60. An additional 75 candidates are under

evaluation and have an estimated savings of $35 million. The runout savings are estimated at approximately $450 million. The cumulative cost of the program, including the 1984 budget, is $39 million. This figure also includes studies that will lead to even more program savings. Another method the project has utilized for reducing cost is through the use of incentive fee contracts. Cost savings by the contractor will be shared by the Government and the contractor.

b. The producibility cost savings identified above result in a projected average unit cost (cost/flight) savings of $1.9 million per tank over the entire mission model of 237 flights.

QUESTION 33:

a. What is the total investment of tooling, equipment, and facilities needed to increase external tank production capability from that which existed at the end of the development program to a production capability of 24 flights per year?

b. What additional investment would be needed to achieve 40 missions per year?

ANSWER 33:

a. The current estimate for the FY 1984-1987 additional investment required to increase the external tank production capability to 24 per year is $150 million (in Fy 1984 dollars). The facilities investment element of this estimate is $12 million, the amount which is included in the FY 1984 request.

b. For an added facilities investment estimated to be approximately $75 million and an R&D tooling investment estimated at $125 million to $130 million, a 40 missions per year production capability could be brought on-line.

QUESTION 34:

Will relocation of SRB refurbishment facility at Marshall increase the number of hardware shipsets required? Will transportation costs be increased?

ANSWER 34:

We are in the process of evaluating the various options for the location of the refurbishment facility. One of the factors which is a parameter in the assessment is the rotating stock of hardware shipsets required. In addition, transportation cost is also a key factor being considered. To date, the analysis has not been completed, but will be forwarded to the Committee as soon as the assessment is completed.

QUESTION 35:

What will be the impact on long term operations costs of relocation of the solid rocket booster refurbishment facility at Marshall?

ANSWER 35:

The various facility options under assessment include the effects on long term operational costs. The efficiency of operations is critical to a final decision and includes such factors as hardware moves, effects on turnaround time, manpower requirements, safety, etc. The differences in operational costs will be forwarded as soon as the evaluation is completed.

QUESTION 36:

From a technical and logistics point of view, what is the best location for the solid rocket booster refurbishment facility?

ANSWER 36:

As indicated in the previous questions concerning the refurbishment facility location, both the technical aspects and the effect on logistics are part of the overall assessment and will be provided as soon as the ongoing assessment is completed.

QUESTION 37:

What are the major challenges which you foresee in achieving a solid rocket booster capability of 24 flights per year?

ANSWER 37:

The major challenge in achieving a solid rocket booster capability of 24 flights per year is in providing a booster refurbishment and subassembly processing facility. Other challenges include improvements in the thermal protection system, the thrust vector control system and the efficiency of the overall flow at KSC.

QUESTION 38:

What is the total investment in tooling equipment and facility required to increase solid rocket booster capability from that which existed at the end of the development program to an operational capability of 24 flights per year?

ANSWER 38:

Depending upon the location of the refurbishment and subassembly facility (RSF) for the processing of booster subassembly hardware, the facility investment could vary. The plan until recently called for investing an additional $3 million in CoF requirements at KSC for necessary facilities in the disassembly area and doing the RSF work off-site through United Space Boosters Incorporated (USBI) corporate investment. At the present time, the location of the RSF is under review and the facility investment requirements may change.

The facility investment for the increasing solid rocket motor build capability to 24 per year will be approximately $20 million and is likely to be a corporate investment by Morton Thiokol. The total project R&D tooling investment, to achieve a 24 per year build rate, may vary as a function of RSF location but should remain in the neighborhood of $70 million additional between FY 1984 and FY 1987.

QUESTION 39:

a. What is the status of the filament wound case development?

b. What is the total cost estimate of this development?

c. How has this estimate changed in the past year?

d. How does the unit cost for filament wound case compare with the unit cost of steel cases?

ANSWER 39:

a. At present, material strength is being characterized from subscale burst tests which will be completed by June 1983. The burst test derived fiber strength design allowables will be used to establish full scale filament wound case motor design. The program is behind schedule (1-2 months) with a recovery plan in place which will support the three full scale static firings and the first flight in October 1985. In addition, integration analyses are underway to determine the impact of the filament wound case on the launch site facilities due to the decreased stiffness of filament wound case vs. steel cases at lift-off.

b. The total cost in the FY 1984 budget to Congress for Morton Thiokol/Hercules-Votaw filament wound case development program is $173 million. This funding also includes MSFC SRB integration. An additional $41 million is allocated for systems integration work by other elements.

c. The total program cost estimate for development and production of the initial flight sets has decreased from the $250 million (in 1983 dollars) estimate contained in the FY 1983 budget runout to $214 million (in real-year dollars) --exclusive of $9 million of previous efforts--in the FY 1984 budget.

d. At present, the cost for filament wound cases is approximately the same as for steel cases. The final cost of filament wound cases will be determined by the reusability of the filament wound case. This knowledge will be gained through tests and actual launch experience.

QUESTION 40:

a. What has been learned regarding the ability to retrieve and reuse the solid rocket booster?

b. How does the flight damage being experienced compare with that which was projected?

ANSWER 40:

a. The reusability concept of the solid rocket booster was proven in the Space Shuttle design, development, test & evaluation phase. Solid rocket motor cases from early flights have been refurbished, and a number of case segments flown on STS-1 will be reflown on the STS-6. The aft booster assembly (aft skirt with installed components) sustained greater water impact damage than

anticipated in early flights requiring repair in addition to refurbishment. Design changes are being implemented to eliminate this problem. The forward booster assembly (forward skirt, frustum, and installed components) is performing as planned and has demonstrated an ability to be reused with the planned refurbishment.

b. Damage to the booster assembly (aft skirts with components) has been somewhat greater than projected due to incidence of higher water impact loads. Otherwise, flight experience has exceeded expectations.

QUESTION 41:

What are the primary steps (work tasks) in refurbishing a solid rocket booster from time to retrieval to a "ready for stacking" status?

ANSWER 41:

The major steps include the following: (1) Retrieval of the booster from the ocean; (2) Demate of the booster once it is brought on the dock, which includes separating the motor into its four major segments (returned to Morton Thiokol for refurbishment) and demating the aft skirt and forward skirt. (3) The auxiliary power system which is located in the aft skirt is safed; that is, the propellant is purged and the system is cleared so that there are no dangerous fumes in the area. (4) The thrust vector control subsystem is removed from the aft skirt, the electrical and instrumentation system is removed from the forward skirts, and the parachute containers are removed from the frustum. (5) The thermal protection system is removed, and the surface of the structure is repainted. (6) The refurbished systems (electrical, thrust vector control, parachutes) are installed into the structures. (7) The aft skirt, with the TVC system, is taken to a hot fire facility to conduct a full duration firing test. (8) The thermal protection system is installed on all primary structural surfaces. (9) The assemblies undergo acceptance tests and final assembly, and are then ready to be transferred to the multiple launch platform for stacking.

QUESTION 42:

a. What inspection techniques are used after retrieval to determine whether each component is acceptable for reflight?

b. Where is each inspection presently performed?

c. Who performs it and who accepts or approves the inspection?

d. What error rate does NASA anticipate in inspection?

ANSWER 42:

a. The inspection techniques used after retrieval to determine whether each component is acceptable for reflight can be separated into two categories: Safing and Disassembly Operations and Refurbishment/Assembly Operations.

Typical operations included in Safing and Disassembly are:

- "As flown" condition checks and assessment
- Disassembly check of major assemblies
- Visual checks of line replacement units (LRU's) and assemblies for damage after removal

Typical refurbishment/assembly operations are:

- Functional test of LRU's "as flown" condition
- Disassembly and inspection to component level
- X-ray and dye penetrant of critical welds
- Dimensional inspection of critical attributes
- Detail wear and damage assessment
- Reassembled and inspected to "new" hardware techniques
- Retest to "new" hardware requirements

b. Refurbishment/assembly inspections are performed at KSC. Manufacturing inspections are conducted at Huntsville and vendor and subcontractor plants.

c. Inspection/acceptance is presently performed as follows:

- USBI refurbishment and assembly inspectors at KSC
- USBI manufacturing inspectors at Huntsville
- Vendor, subcontractor and USBI inspectors at vendor plants
- NASA inspectors at KSC
- DCAS inspectors at all other sites (vendors)

Who accepts?

- USBI quality assurance
- NASA/DCAS
- Vendor quality assurance

d. It is anticipated that the error rate in inspection will not exceed the error rate of "new" build hardware for line replacement units (LRU's) and components.

QUESTION 43:

a. What components does NASA believe will not pass inspection after the first flight?

b. Will NASA please furnish, for the record, an estimated schedule of each component, identifying the anticipated useful life of each by number of flights?

ANSWER 43:

a. The solid rocket boosters, exclusive of the solid rocket motors, consist of both reusable and expendable hardware components. Over 3000 configured piece parts make up a booster, of which over 90 percent are reusable. The expendable parts consist primarily of propellants, the separation motors, some electrical cables, thermal protection system pyrotechnics, nose cap, pilot chute, etc. As a result of flights to date, all of the hardware designed for reuse has been found to be refurbishable and capable of

reuse. However, there are some components that require extensive refurbishment due to damage at water impact. Specifically, these components were part of the thrust vector control system located inside the aft skirt assembly and, in addition, the aft skirt structure. With the improvements to be incorporated to reduce water impact damage, virtually all of the reusable hardware components should pass inspection after first flight.

b. The anticipated useful life of SRM/SRB components is summarized in the following table:

COMPONENT NAME	DESIGN LIFE (# USES)	COMPONENT NAME	DESIGN LIFE (# USES)
SRM		SRB	
Aft cylinder	20	Integrated electronic assembly	20
Fwd. cylinder	20	Alt. switch	20
Cylind. Segments	20		
Fwd. dome	20	Radio frequency beacon	20
Attach segment	20	Rate gyro	20
Aft dome	20	Reusable cable	20
Aft stiff. tee's	40	Sensors	20
Joint hdw.	20	Thurst vector control actuator	20
Noz. comp. ring	20	Thurst vector control power supply	20
Noz. other parts	20	Thurst vector control frame/bracket	20
Noz. bearing shims	20	Nose frustum	40
Noz. aft end ring	20	Fwd. skirt	40
Noz. fwd. end ring	20	Tunnel	40
Igniter	20	Reusable struts	40
		ET attach ring	40
		Aft skirt	40
		Drogue	10
		Main chute	10
		Parachute location aid	10
		Isogrid	40

QUESTION 44:

Will NASA please furnish, for the record, flow charts showing the movement of components from retrieval through stacking?

ANSWER 44:

As indicated previously, we are in the process of evaluating various options for the SRB manufacturing facility. Component movement from retrieval through stacking will vary somewhat depending upon the option selected.

We will forward the information requested as soon as it becomes available.

QUESTION 45:

Relating to the flow charts, will NASA please furnish, for the record, the refurbishment work stations, the work tasks at each station, and the principal tooling required at each station? In addition, please identify the environmental standard which must be maintained at each work station.

ANSWER 45:

As indicated previously, we are in the process of evaluating various options for the SRB manufacturing facility. The refurbishment work stations, component movement between work stations, as well as principal tooling requirements, will vary somewhat depending upon the refurbishment and subassembly facilities option selected.

We will forward the information requested as soon as it becomes available. Environmental standards maintained at each work station will be in accordance with OSHA standards and those set forth by the American Conference of Government and Industrial Hygienists (ACCIH). The environmental assessment for the existing SRB refurbishment facility is contained in KSC Final Environment Statement, Issue 1979.

QUESTION 46:

a. Will NASA please furnish, for the record, the estimated residence time required for work at each station?

b. What degree of confidence does NASA have in the estimated residence time at each work station -- and of these estimates -- which ones are supported by experience? Given that there have only been four shipsets returned, what does NASA calculate at the lower and upper limits of total through-put time for one shipset?

ANSWER 46:

a. As indicated previously, we are in the process of evaluating various options for the SRB manufacturing facility. The residence time at each work station will vary somewhat depending upon the refurbishment and subassembly facilities option selected.

We will forward the information requested as soon as it becomes available.

b. As indicated previously, we are in the process of evaluating various options for the SRB manufacturing facility. A major purpose of relocation is to increase refurbishment/production efficiency. Therefore, present experience, along with improvements expected, will be used to update through-put times as necessary when the refurbishment and subassembly facilities option is selected.

The information requested will be furnished as soon as it becomes available.

QUESTION 47:

What calculations has NASA made to transcribe work tasks to functional facility requirements defining four areas: overhead clearances, transport tooling, in process inventory space requirements, and utility support systems? Please furnish information, for the record, which defines in detail the facility requirements.

ANSWER 47:

As indicated previously, we are in the process of evaluating various options for the SRB manufacturing facility. All options include, but are not limited to, definition of functional facility requirements in areas such as overhead clearances, transport tooling, in process inventory space requirements, and utility support systems.

We will forward the information as soon as it becomes available.

QUESTION 48:

In identifying existing facilities which could be used, and as a preliminary step to cost estimating, what facility alternatives has NASA identified as being optimum to support solid rocket booster refurbishment? Please describe these alternatives.

ANSWER 48:

As indicated previously, we are in the process of evaluating various options for the solid rocket booster manufacturing facility. Options being evaluated include existing, on-site, off-site, government, and contractor furnished facilities.

We will furnish the information requested as soon as it becomes available.

QUESTION 49:

What does NASA now consider its facility options and how far does each fall short of optimum? In what respects?

ANSWER 49:

As indicated previously, we are in the process of evaluating various options for the SRB manufacturing facility. All options under consideration will support a launch rate of 24 per year with growth potential.

We will forward the information requested as soon as it becomes available.

QUESTION 50:

a. Effective organization and communication would seem to be essential to rapid cost-effective refurbishment. Communication between supervisors working on the same refurbishment project, as opposed to working on separate and distinct components which would be assembled at some remote location in the future, would appear to be

of paramount importance. The most effective communication seems to be those which are made in person and "in real time." Please describe how NASA will accomplish this?

b. What is the overall refurbishment through-put time that NASA estimates for meeting a flight rate of 24 launches per year?

ANSWER 50:

a. NASA plans to have all manufacturing (refurbish/assembly) activities located in the same general proximity. Therefore, person-to-person "real time" communications will be available. This applies to all options being evaluated.

b. As indicated previously, we are in the process of evaluating various options for the SRB manufacturing facility. Timelines (through-put times) are part of the options being evaluated. These are factors in meeting a flight rate of 24 launches per year with growth potential.

We will forward the information as soon as it becomes available.

QUESTION 51:

NASA will have to hire additional personnel to meet a 24 flights per year schedule. What qualifications and experience will be required for "touch labor" to meet this schedule?

ANSWER 51:

As indicated previously, we are in the process of evaluating various options for the SRB manufacturing facility. The SRB refurbishment contractor will require additional personnel to support a launch rate of 24 per year. This will require a skill mix which is available at any of the option sites selected.

QUESTION 52:

When will NASA resolve the facility problem?

ANSWER 52:

NASA plans to complete the review of various options in the next several weeks. At your convenience, we will present the results of our evaluation.

QUESTION 53:

Please describe NASA's quality control program for refurbishment?

ANSWER 53:

NASA's quality control program for refurbishment includes the following inspections and tests:

- Functional test of line replacement units (LRU's) "as flown" condition
- Disassembly and inspection to component level

- X-ray and dye penetrant of critical welds
- Dimensional inspection of critical attributes
- Detail wear and damage assessment
- Reassembled and inspected to "new" hardware techniques
- Retest to "new" hardware requirements

QUESTION 54:

What is the present cost for refurbishment for one shipset and what is the present cost for propellant and solid rocket motor components?

ANSWER 54:

Present cost, FY 1983 dollars, for refurbishment of one SRB shipset (SRB/SRM) is approximately $24 million. Present cost, FY 1983 dollars, for propellant and motor expendable materials is $5.8 million.

QUESTION 55:

Are adequate logistics procedures being developed and implemented on a timely basis?

ANSWER 55:

Logistics policies, plans, and procedures have been in place for a number of years covering the design, development, test, and evaluation and transition to operational phases. These policies, plans, and procedures were prepared and implemented to set up a basis for the spares acquisition maintenance and repair, transportation, training and maintenance documentation that would be necessary to support the Space Shuttle initial operation. The logistics planning was accomplished without the benefit of any flight experience. With the acquisition of data from five flights, policies, plans, and procedures for an integrated logistics system in an operational environment are being updated, modified or rewritten.
Policy and guidance from Headquarters have been provided through an interim period logistics policy. An Integrated Logistics Support Plan is being prepared by the Shuttle Program Office at JSC. Numerous procedural documents and directives are being prepared by individual project offices at the centers that provide the basis for logistics support to the Space Shuttle operations. Procedures for operational logistics support are in place or are being prepared with the acquisition of actual flight data in a timely manner to support future Space Shuttle operations.

Therefore, we believe that adequate logistics policies and procedures have been and are being put in place in a timely manner.

QUESTION 56:

a. Will the offshore oil and minerals exploration in the solid rocket booster recovery area at the Kennedy launch site affect the U.S. space program and space goals?

b. What are the specific risks and hazards to NASA/Air Force personnel and their facilities and equipment that will be created by the proposed July 1983 leases?

c. What are the specific risks and hazards to the leasee's personnel, facilities, and equipment?

d. What specific actions has NASA taken in cooperation with the Department of the Interior to lessen these risks and hazards and to address the concerns in the March 1982 Air Force and NASA report?

e. Will the lease revenues and the contribution of the leases toward meeting our national resource goals be of greater significance than the impact on the space program?

ANSWER 56:

a. If unrestrained offshore oil and minerals exploration in the solid rocket booster recovery area were permitted, it could possibly affect certain conditions associate with Space Shuttle launches. However, we have been working with the Department of the Interior to define appropriate conditions, so we do not expect any impact on the U.S. space program and space goals.

b. There would be no likely risks to Air Force/NASA personnel or facilities. The only probable risk is the possibility of an SRB impacting any structure within the recovery zone.

c. If proper conditions were not implemented, specific risks and hazards to the lessee's personnel, facilities, and equipment could include:

(1) Death, injury or damage to lessee's facilities and equipment from impact of an empty SRB weighing 172,000 pounds.

(2) Death, injury, or damage by jettisoned external tank while the Shuttle is in an emergency return-to-launch-site mode. Weight of an external tank and the residual propellant would range from 90,000 to 110,000 pounds. Due to the propellant, the tank could explode upon impact.

(3) If it became necessary to destruct the launch vehicle immediately after launch, there could be hazards due to debris from the SRB's, External Tank, and Orbiter.

d. Since the onset of the South Atlantic Area oil and mineral exploration program, NASA has continually worked with Department of the Interior to avoid any and all unreasonable risks in the area of the Kennedy Space Center Flight Clearance Zone.

e. NASA cannot comment on lease revenue and mineral production potential to meet national resource goals. However, since NASA and Interior have been actively working the issue, it is only reasonable to expect a final resolution that benefits the country with essentially no impact on the space program.

QUESTION 57:

The size of NASA's astronaut corps seems somewhat inflexible to changing mission requirements. As NASA begins the Shuttle operations era, there is one primary planning issue: Are there alternative recruitment and training procedures that could better provide for NASA's astronaut requirements?

ANSWER 57:

As we begin the Shuttle operations era, all elements of the program are being examined to insure that we are fully prepared for efficient, high-flight-rate operations. The requirements for NASA astronauts are among those elements being examined. We are currently reviewing our recruiting strategies and training procedures in view of our entry into the operational era and we intend to update these during this summer. This update certainly will take into account, as a minimum, our experience base to date and the need for flexibility to changing mission requirements.

QUESTION 58:

In 1977 GAO pointed out that NASA had not established accounting procedures to accumulate Shuttle operations costs. NASA officials said then that they had placed their priority on establishing a preliminary user charge policy and had not yet established the necessary accounting policies and procedures to implement this policy. The overall question is: What changes need to be made to NASA's current accounting system and procedures to provide adequate data for NASA to manage STS and carry out its STS pricing policy?

ANSWER 58:

No basic changes are required. Installations may need to develop further discipline within their respective procedures and refine certain allocation methods to insure full and accurate cost accruals. However, each installation presently has a satisfactory job order cost system in place.

QUESTION 59:

NASA's initial design goal was for Shuttle turnaround time not to exceed 160 hours. NASA's most recent estimate was for an 888 hour Shuttle turnaround time by its 26th operational launch. As the turnaround time increases, more facilites are needed to maintain the Shuttle launch rate. The questions are:

a. What will these facilities cost?

b. What will the effect of these facilities' costs be on NASA's budgets?

c. What are cost of DOD's security requirements at these facilities?

d. What effect will the DOD security requirements have on NASA's normal STS Operations?

ANSWER 59:

a. Through FY 1983, the total investment in facilities for the Space Shuttle at the Kennedy Space Center amounts to approximately $240 million. The FY 1984 budget contains a request for an additional $27 million for a third mobile launcher platform. With the exception of the pending consideration within NASA of the solid rocket booster refurbishment and subassembly facility, this investment in facilities through FY 1984 provides the capability to support at least 18 flights per year from KSC. Although the turnaround time has increased substantially from the initial 160 hour program goal for mature operations, we believe the facilities now in place and the additional facilities to be completed by 1986 will support the 24 per year flight rate for launches from both the east coast and west coast launch sites.

b. As noted above the FY 1984 budget supports the 24 per year launch rate. If a later decision is made that the future planned utilization of the Space Shuttle warrants providing for higher flight rates, this would entail making additional investments at the launch sites, and as well as additional funding for procurement of orbiters external tank and solid rocket booster production capabilities, and mission support facilities.

c. The DOD's security provisions for the turnaround facilities will cost approximately $126 million over 11 years. For the five prior years including FY 1982, approximately $19 million was obligated. FY 1983 is the major implementation year with planned obligations of $37.7 million, followed by FY 1984 with $15.7 million.

These figures do not include CoF at $12.1 million over 8 years. Approximately $1.6 million was spent through FY 1982 and expenditures of $9.9 million are planned for FY 1983.

d. We do not believe there will be any major effects on the turnaround schedule due to DOD security requirements. The implemented security provisions will provide a secure environment for both classified payload operations and unclassified Space Shuttle operations as appropriate.

QUESTION 60:

NASA plans to continue STS development to achieve design requirements and fund Shuttle enhancement to achieve payload savings through satellite retrieval, on-orbit maintenance, or return to earth for refurbishment. Will satellite services equipment and the orbital transfer vehicles being developed by NASA provide sufficient on-orbit capability to meet user requirements in a timely manner?

ANSWER 60:

Yes. We are studying the merits of a teleoperator maneuvering system to emplace and retrieve satellites for servicing at the orbiter, and eventually to service satellites in their own orbits. In addition, we are investigating refueling and servicing kits. An orbit transfer vehicle is also a potential element in our future planning. The evaluation of user requirements and the costs and benefits of proceeding with such potential developments is an essential part of the process.

QUESTION 61:

a. What is the status of planning for a Cargo Processing Contract at Kennedy Space Center?

b. When is the procurement currently planned?

ANSWER 61:

a. The cargo processing contract (CPC) is in the very early planning stage. A procurement team has been formed at the KSC to address the issues of the CPC planning effort, which include among others: how to insure an open competition; the appropriate future rolls and missions of the KSC civil service work force; the proper relationship of the CPC to the SPC, BOC, and the Government; the inclusion of VAFB cargo operations into the contract; and the timing of the procurement.

b. Current planning strategy is predicated on incorporating into the cargo processing contract as much experience as possible from the Shuttle processing contract procurement. Since the development of an accurate statement of work for the cargo processing contract cannot be accomplished until after the Shuttle processing contract is on-board and has attained some degree of maturity, the earliest possible date for selection of the cargo processing contract appears to be the spring of 1985.

QUESTION 62:

NASA and DOD have concluded an agreement to develop a modified Centaur for use with the Space Shuttle.

a. What are the significant principles of this agreement?

b. What is the total development cost, including facilities and Shuttle integration costs (provide a breakdown by type of activity and by fiscal year)?

c. Have these estimates changed in the past nine months?

d. How are the costs divided between NASA and DOD?

ANSWER 62:

a. The significant principles of this agreement are: 1) The project will be a jointly funded effort for a baseline common, short, wide-body Centaur, designated Centaur-G, and related support equipment; 2) separately funded procurement and production actions will provide four initial vehicles: two short Centaur-G's for DOD and two long derivative Centaur vehicles, designated Centaur G-prime, for NASA; 3) the production costs of flight hardware will be borne by the respective user; 4) costs associated with unique mission requirements will be borne by the respective user; 5) overall Centaur-G project management responsibilities will reside with NASA and a joint project office will be established with a NASA project manager and an Air Force Deputy project manager; 6) the Air Force and NASA will equally share common design and development cost for the cryogenic upper stage Centaur-G; 7) the Air Force and NASA have established a target cost of $269 million for the joint development of Centaur-G with the proviso that the program will be structured to insure that the cost to the Air Force will not exceed $150 million; 8) a major development objective will be to remain within the critical cost and schedule parameters defined in this agreement; 9) indication that annual budgets or overall cost estimates will be exceeded, or that the initial operating capability date of early 1986 will not be met, will cause a joint high-level NASA/DOD review to be held; 10) security missions will be priority in case of schedule conflicts which would impact national security; 11) the project will result in delivery of two Centaur G-prime vehicles to support the Galileo mission and the International Solar Polar Mission currently scheduled for launch in May 1986, and two Centaur-G vehicles to support DOD missions in mid-1987; 12) in addition to the common design and development project, NASA will budget and fund for: modifications to Shuttle orbiter vehicles 099, 104, and subsequent orbiters, as required; modifications to Kennedy Space Center facilities necessary for common Centaur-G operations, integration of the common Centaur-G into the Space Transportation System, and any hardware production cost associated with NASA sponsored missions.

b. See attached chart.

c. The estimates for the base program have not changed significantly over the past nine months. We have adjusted the out years by new inflation factors and added the development of the Centaur G-prime/STS as a result of the DOD/NASA MOA Agreements.

d. See attached chart.

QUESTION 63:

What is the status of NASA plans for the Delta and Atlas-Centaur launch vehicles?

FY 1984 BUDGET TO CONGRESS
CENTAUR/STS DDT&E FUNDING

	Prior	FY83	FY84	FY85	FY86	FY87	FY88	Total
CENTAUR/STS DDT&E	85.5	182.6	163.6	99.0	15.8	2.7	--	549.2
FUNDING SPLIT								
DOD CENTAUR-G	--	10.0	34.2	69.3	11.5	3.1	--	128.1
NASA G & G-PRIME	55.5	115.0	80.9	.3	--	--	--	251.7
NASA ORB/KSC MODS & PAD B ACCEL.	30.0	57.6	48.5	29.4	4.3	-.4	--	169.4

ANSWER 63:

NASA plans to launch Delta at least until about 1986, and the Atlas-Centaur launch vehicles to about 1987 to support current firm commitments to customers. Delta and Atlas-Centaur launch vehicles are under contract, being manufactured and produced for this purpose. Since it takes approximately three years from the inception of contract go-ahead of manufacturing to the time of launching these vehicles, a customer must plan and commit this way.

For the Delta and Atlas-Centaur program, a minimum ongoing rate of three to four vehicles per year production and launch is desirable for efficiency, economy and reliability. Currently, such a program is in effect as Delta and Atlas-Centaur users transition to the Shuttle. However, since the operational Shuttle appears to be able to accommodate requests for launch services, the maintenance and operation of these systems by the Government solely as backup to the Shuttle may be too costly and not justifiable.

The current planning, therefore, is to phase out the Government's involvement in these expendable launch vehicles after the firm commitments have been fulfilled.

QUESTION 64:

Does NASA believe that expendable launch vehicles should be commercialized?

ANSWER 64:

Yes. It is NASA and national policy that the United States encourage domestic exploitation of space activities under appropriate U.S. Government authorization and supervision. The most recent restatement of this policy occurred in July 1982, when President Reagan announced the expanding of the private sector investment and involvement in civil space and space-related activities as a basic goal of U.S. Space Policy. With respect to expendable launch vehicles, the announcement was more specific, stating that expendable launch vehicle operations should be continued by the U.S. Government until the capabilities of the STS (Space Shuttle) are sufficient to meet its needs. Beyond this time frame, the policy, therefore, does not endorse nor prohibit their turnover to the private sector.

We are in process of establishing an Agency position on commercialization, reviewing it both internally, and as a member of the Senior Interagency Group (SIG-SPACE). While this effort is not complete, the preliminary conclusion reached is consistent with the recently signed space policy.

QUESTION 65:

Does not a limited orbiter fleet and a plan to phase out expendable launch vehicles improve the competitive posture of foreign launch systems?

ANSWER 65:

This would be the case if potential customers are not convinced that the U.S launch capability has the depth and resiliency to handle their launch requirements, both promptly and reliably. However, the Administration has stated clearly that the U.S. primary launch vehicle should be the Space Shuttle and this system must, therefore, be supported fully. That is the rationale for the proposed STS orbiter structural spares program, to provide the necessary assurance for the Nation to operate the orbiter fleet in a robust manner. Accordingly, we believe these actions will bolster the confidence of potential customers in the long-term viability of the national Space Transportation System.

QUESTION 66:

Has the Senior Interagency Group taken a position on the commercialization of expendable launch vehicles?

ANSWER 66:

Not at the present time. The Interagency Space Launch Policy Working Group is reviewing commercialization of expendable launch vehicles and is scheduled to report to the Interagency Group (Space) about mid-April 1983. This group will, in turn, report to the Senior Interagency Group, but a date has not yet been established.

QUESTION 67:

Do you expect the Senior Interagency Group to be involved in such a decision?

ANSWER 67:

Through the mechanism described above, the Senior Interagency Group (SIG) will be involved in the policy formulation on commercialization. It is anticipated that the SIG will make a recommendation to the National Security Council on commercialization of expendable launch vehicles.

QUESTION 68:

What is NASA's policy on providing orbital service to the STS user--payload deployment, retrieval, servicing?

ANSWER 68:

NASA's policy is to provide full and complete coverage for all STS user requirements for payload deployment, retrieval and servicing to the maximum extent consistent with STS capabilities. These services are provided on a reimbursable basis.

QUESTION 69:

It is our understanding that the Office of Space Flight has been studying a teleoperator maneuvering system for several years and that it offers significant benefits to the user and STS operations generally. What is the status of NASA's planning for such a system?

ANSWER 69:

We have completed a preliminary concept definition and are now in the process of firming up requirements and identifying potential users.

QUESTION 70:

Are there funds in the budget to continue the teleoperator program and get it into development?

ANSWER 70:

The pending budget request contains provision for continuing concept and requirements definition studies. Funds for system definition and development will be considered within the budget formulation process for future budgets.

QUESTION 71:

Since the teleoperator system apparently can help to bring the STS up to its planned capability of services to the payload community and also reduce their payload development costs--could it be funded as a part of the STS capability development, like the external tank and the solid rocket boosters? Is private sector financing of such a capability viable?

ANSWER 71:

Funding for the development of such a system is not currently contained in the budget runout for STS production and capability development, but--if approved--would be requested under this budget line item. Private section financing may be a viable possibility, although the companies with which we have had discussions have not yet seen sufficient profit potential to warrant such a venture.

QUESTION 72:

How much funding is being requested in FY 1984 for a procurement of a second set of Spacelab hardware?

ANSWER 72:

In FY 1984, the requested amounts for the procurement of the second Spacelab is $28.9 million.

QUESTION 73:

What is the status of planning for establishment of a Spacelab pricing policy?

ANSWER 73:

NASA has spent significant effort on developing Spacelab operations cost estimates. Considering we have not flown the first mission (Spacelab 1), we believe it would be appropriate to gather more accurate data prior to establishing a price for Spacelab missions. A pricing policy will be issued as soon as feasible.

QUESTION 74:

What is the total investment of the United States in Spacelab development?

ANSWER 74:

The total investment by the United States through FY 1983 in the Spacelab development is approximately $481 million. At completion, the present estimate amounts to about $605 million. This includes development of various hardware and support equipment, integration and processing of the Spacelab 1 and Spacelab 2 missions and the purchase of the second Spacelab unit from Europe. These costs do not include other related items such as experiments, data analyses, and related launch, C of F or R&PM costs.

QUESTION 75:

Could you elaborate on the impact of any Shuttle launch delay on the science return for Spacelab's first mission?

ANSWER 75:

Spacelab 1 is currently scheduled for a launch on September 30, 1983. The baseline mission plan was predicated on the availability of an operational two TDRS system, as well as having the time needed for pre-launch training simulations of the mission. The science return from the mission depends on the time available for both uplink communication for voice and commands, and the volume of data that can be downlinked to the ground. Delays in the launch of TDRS-A on STS-6 and for TDRS-B on STS-8 could reduce the science return for Spacelab 1 launched in September 1983. The Spacelab 1 launch date is under review but contingency planning is underway to determine how Spacelab objectives can be met to the extent possible, if full TDRSS coverage is not available.

QUESTION 76:

If Congress added $40 - $50 million to the Space Shutle program, how would you use it?

ANSWER 76:

In NASA's deliberations leading to the FY 1984 budget recommendations to the OMB and the FY 1984 budget request to the Congress, the Agency attempted to formulate a balanced budget plan for the entire aeronautics and space activities.

In addition, the Administration's decisions on the total Federal Government budget recommendations were based on a similar approach of carefully balance total requirements against funding availability. Therefore, given this total Federal budget consideration, it would be inappropriate for NASA to respond to any inquiry concerning potential additional funding for the Shuttle or any other program above that identified in the current budget request.

QUESTION 77:

What would be the impact of a $10 million reduction in the Spacelab procurement?

ANSWER 77:

A follow-on procurement cut of $10 million in FY 1984 would delay the availability of important spares and would reduce NASA's ability to correct problems in the follow-on unit resulting from the first flight test of Spacelab. These two impacts could significantly increase program risk and require additional funding in subsequent budget requests.

QUESTION 78:

What would be the impact of a reduction in the funding for orbiter spares?

ANSWER 78:

A reduction in funding for orbiter flight spares would have many impacts.

The first impact would be an increase in program risk by not having necessary parts available when needed. This could cause a schedule delay or the cannibalizing of parts from other vehicles. Reductions could also mean the loss of some subcontractors who produce the spares because they are now finishing their OV-104 work and will close down their orbiter production effort if there is not follow-on work. This would result in high cost penalties when the needed spares are procured at a later date. These penalties would result from start-up costs, new source qualifications, etc.

QUESTION 79:

What would be the impact of a $5 to 10 million reduction in the funding for orbiter spares?

ANSWER 79:

A reduction of $5 to $10 million in flight spares would postpone purchase of some spares and increase the possibility that these spares would not be available when needed and that there would be significant restart up costs. Due to earlier constraints on program

funding, NASA has, at times, had to satisfy spares requirements by cannibalizing the next vehicle in production; this method will soon no longer be available. A reduction in available spares could consequently increase the risk to the planned flight rate.

QUESTION 80:

What would be the impact of $5 to $10 million reduction in the engineering and technical base funding?

ANSWER 80:

The engineering and technical base (ETB) was established in FY 1983 to fund a minimum technical support capability necessary to support various space transportation systems elements. In establishing this base, NASA defined only those activities and facilities which represented the core support for R&D capabilities.

It should be noted that the current ETB estimate of $70.3 million for FY 1983 was reduced by $12.1 million in the FY 1983 Operating Plan. This reduction was the result of several actions taken in FY 1982 which made more obligational authority available to carry over and apply against FY 1983 requirements.

The FY 1984 budget request--when compared to the total funding plan for FY 1983--represents an increase over the FY 1983 level primarily due to the effects of inflation on wages and other costs. Since the ETB budget is manpower intensive, a reduction of $5 to 10 million in this area would result in a reduction in the level of contractor manpower supporting laboratories and sustaining engineering at all four Office of Space Flight centers by approximately 150-300 work years. This reduction would be unacceptable, and, therefore, the funding for these requirements would have to be absorbed primarily by the Shuttle program.

QUESTION 81:

What would be the impact of the $15 to 20 million reduction in Shuttle Operations funding?

ANSWER 81:

At KSC, the Shuttle processing contract is to be implemented in FY 1984. Until this contract is negotiated, we do not know precisely what penalty will be incurred due to the overlap associated with transition. Assuming KSC's share of the reduction is $10 million, it is within the range of uncertainty of the estimate and, therefore, translates into a management risk. At JSC, we are funding the tools to support future flight rates while sustaining present operations. A reduction in funding, therefore, could add risk to the near-term flight rate.

Mr. VOLKMER. Thank you very much, General Abrahamson.

At this time I will recognize the gentleman from Florida, who has some questions.

Mr. NELSON. Thank you, Mr. Chairman, and thank you for accommodating me so that I can get out to the airport to catch a plane south.

General, why don't you just take the two questions that I sent you in the letter of February 22, and address those, please?

General ABRAHAMSON. Yes, sir.

Your first question was about the SRB refurbishment activity. This is the refurbishment of the SRB frustrums and the aft cone. After we go into flight, we separate the SRB's and they are dropped by parachute into the ocean. We recover them, bring them back, refurbish them, and send them up again on a later flight. This activity has been on going in the vehicle assembly building at KSC, Mr. Nelson asked why this was not a portion of the shuttle processing contract. The SPC is the consolidated effort to make operations more economical and more efficient at Cape Kennedy.

We examined that very carefully, Mr. Nelson. Indeed, it was a difficult decision. We felt that there were certain characteristics of the activities for the SPC that were common activities that are processing or maintenance related. In fact, the SRB refurbishment is more of a factory operation and has posed a fundamental problem. The refurbishment had been set up in the vehicle assembly building for short-term economies. unfortunately, we are hampered by facility limitations and safety considerations in such a way that an efficient manufacturing flow is not possible at higher production rates needed in the future.

Therefore, we felt that the more that we could get this into a manufacturing environment and separate both its management and its support from the day-to-day processing that goes on, the better it would be. There is an additional factor that plays into this equation. The SPC, as a processing activity, is being implemented at a point in time that is possible because of the maturity of the operations. It assumes that the hardware that is being processed does not have significant additional R&D or development activity. We are still getting damage to the SRB's as they enter the water, and we have fixes that are designed but not yet fully implemented. Therefore, we felt that the maturity of the design did not lend itself to a processing activity. There is a cost risk in terms of implementing design changes on the production line at the same time that we are carrying out processing activities.

Mr. NELSON. Would you anticipate, in the future, all of it being folded into the shuttle processing contract?

General ABRAHAMSON. I would not. The processing activity is not a manufacturing activity. If the SRB refurbishment should be associated with anything, we should try to make the overall manufacturing plan for the SRB's as efficient as possible.

Mr. NELSON. In the actual components of the SRB, what percent would be attributed to a manufacturing activity?

General ABRAHAMSON. I have never really thought of it in terms of a percentage. I would like to make that estimate more accurately, sir, if I may.

Mr. NELSON. Sure. To get a concept, an overall concept of what I need, we are looking at a space transportation system that is to be reusable except for the external tank——

General ABRAHAMSON. Yes, sir.

Mr. NELSON. Well, here we do have a function that in fact is not reusable. You are saying that where there are components that have to be remanufactured in the SRB's——

General ABRAHAMSON. Yes, sir, I am. I think that they can be handled more efficiently in a manufacturing environment. They should be remanufactured, but I do not believe that that implies that they are not reusable. NASA wishes to pursue the most efficient way in which they can be handled and be available for the reusability of the overall system.

Mr. NELSON. When you say remanufactured, then, you are talking about reuse of the components?

General ABRAHAMSON. Yes, sir.

Mr. NELSON. Therefore, it is a remanufacturing instead of a reprocessing.

General ABRAHAMSON. Let me contrast it to the orbiter. When the orbiter comes down, we have some parts, replacement activity which we hope is going to be a very minor activity. We should only have to replace a component here or there. Thus, it is really a maintenance activity that I am describing as a normal processing function. But, when the solid rocket booster comes down, the old paint, products of combustion, and rust have to be cleaned off with a water laser. Then, we have to go in and do some repair work. As I indicated, it is more than we would like. However, we are compelled to accomplish the effort. Consequently, I believe that the characteristic of those activities is analogous to a manufacturing function. In fact, some of the automated techniques that we are now developing for that at Marshall and other locations hold promise for making this a much lower-cost activity.

Mr. NELSON. Will that be true when you change from the steel casings for the SRB's to an epoxy-type casing?

General ABRAHAMSON. The requirement for the filament-wound case is to make the design in such a way that it can and will be reusable. That is our objective. We do not yet know how reusable the filament wound case will be, and we are trying a low-cost R&D development to determine this. The developmental philosophy is rather like, "Dump it in the water and see how it comes out each time." Then, we will make a professional judgment about how many times we can successfully do that. It may not appear sophisticated, but, we think that that is the best approach.

Therefore, the answer is "yes." We feel that the filament-wound case will not change our efforts to make this a manufacturing kind of flow. In fact, it will just be a substitute component for the steel casing.

Mr. NELSON. Would it eliminate the removal of that ablative material?

General ABRAHAMSON. It should eliminate some of it, sir. However, but there will still have to be some finishing and some of cleanup. On filament-wound cases, just as with the steel cases we won't be able to allow salt water to stay there and corrode or damage the basic material.

Mr. NELSON. Well, I am just a little country boy who was fortunate to be elected to Congress, and I would say that this is a judgment call——

General ABRAHAMSON. Yes, sir, it is.

Mr. NELSON [continuing.] As to whether or not it is a manufacturing activity or a processing activity. I know that Dick Smith is one of the ones who inaugurated this concept of the shuttle processing contract, where there has been great consternation, by the way at the Kennedy Space Center over this particular thrust.

Nevertheless, under his theory to drive the cost down, we need a more efficient flow of processing for this space transportation system. Therefore, we will be watching that in the future.

Now before I have to dash to the airport, which was 2 minutes ago, could you address the second question, please?

General ABRAHAMSON. Yes, sir.

The second question was: "Do the DOD flights and the slippage in the DOD flights pose a problem or a threat to the competitiveness of the system?" Is that the correct way to state your question?

Mr. NELSON. Yes. I wrote, "Will the lessened launch rate of the shuttle between now and 1988 increase the likelihood that the Air Force will take over operation of the shuttle from NASA, since the shuttle's competitiveness is diminished because of the higher cost per flight?

General ABRAHAMSON. The answer is. "no", sir.

Mr. NELSON. All right. I would like to ask you to submit for the record some additional information. This committee, formally in testimony with many of your people as well as informally, has been quite concerned about the flight of payloads that we think ought to be going on the shuttle that are going to the Ariane, and the fact that there are these statements being made by your agency that you are going to cut back on the frequency of the flights because the payloads are not there. I would like for you to comment on that for the record.

I would like for you to tie in, for example, this letter of June 14, 1982 from Budget Director David Stockman to Jim Beggs, in essence laying down a policy that we should not assume that the Government should have the responsibility to fund an operational system with sufficient capacity to meet non-U.S. needs, once the shuttle technology is developed. That kind of philosophy, if that is invading NASA, seems to me to be a 180° reversal from what was the original theory of the shuttle in the first place, and that is to get a reusable system that is frequently launched, to drive the per-flight cost down, to make it all the more competitive, particularly in the commercial world, as we move into the era of industrialization, of pharmaceutical manufacturing, et cetera, in space. Therefore, I would be most appreciative to you for addressing that at length.

General ABRAHAMSON. Sir, we are prepared to show explicitly what has happened to the various launches or the customers themselves in the first phase, of the program. We are prepared to do that because that was one aspect of the request that you made to Mr. Beggs.

Mr. NELSON. If you would just go on and submit that, I will pick it up and I will get it in written form.

General ABRAHAMSON. Yes, sir. We will be happy to submit in greater detail the answer to the questions that you have raised.

Mr. NELSON. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you, Mr. Nelson.

General, I would like to get back to the engines, very briefly. Let me ask you this, now. As I understand it, has 2012 been pulled?

General ABRAHAMSON. The status right now, today, is that 2015 has already been pulled.

Mr. VOLKMER. All right.

General ABRAHAMSON. Relative to 2012, it is raining on the pad. We expect 2012 to be out this evening if the rain does not slow us down too much; 2012 will be shipped from the NSTL, where it has been tested.

Mr. VOLKMER. It has not been shipped yet?

General ABRAHAMSON. No, sir. It is now going through a last bagging procedure because we did have a slight leak at a flange, and that will be completed within the next 2 days, then the engine can be shipped. By the way, that is not on our overall schedule's critical path. The critical path is the repair that we are now making on engine 2014, which is, in a sense, our pathfinder.

Mr. VOLKMER. Right. It is the cert engine.

General ABRAHAMSON. Yes, sir. It is the certification engine, but on the repair itself, it is also the pathfinder, in the sense that we are testing the repair procedure on that engine. The repair should be completed tonight; we will then take the engine back, put it on the test stand, and fire it for a full 500-second run. That process will be the proof of our repair.

Mr. VOLKMER. That is on the sleeve portion?

General ABRAHAMSON. We are not going to put on a sleeve. The repair is——

Mr. VOLKMER. I know. I mean, you're going to take out the sleeve, as I understand it, and put a part in there, and you are going to do that on 14?

General ABRAHAMSON. Yes, sir, that is correct. We will do that on 2014 first.

Mr. VOLKMER. If it all works out, then you are going to do it on 12, 15, and 17. Right?

General ABRAHAMSON. On the other three engines, yes, sir.

Mr. VOLKMER. You plan to do that even though on 17, as I understand it, it shows no sign of leaking on that engine.

General ABRAHAMSON. Yes, sir.

Mr. VOLKMER. It has been boroscoped and everything?

General ABRAHAMSON. Correct.

Mr. VOLKMER. OK, so our schedule is put back maybe another week.

General ABRAHAMSON. I am estimating that the schedule is at best somewhere around the 26th or 27th without new problems, and, nearly the end of the month. So that we will incur about a 7- to 10-day additional slip.

Mr. VOLKMER. Now the budget projections for STS, your Space Transportation System activities, in reviewing them, have increased significantly in the past year. I looked at the February 1982 projection for fiscal years 1983, 1984, 1985, 1986, and 1987, and then I looked at this year, the February 1983 projections for the

same time period, and I find a cumulative approximate $1.2 billion increase over that period of 5 years. Can you tell me where that need comes from?

General ABRAHAMSON. The outyears of the shuttle had been too optimistically projected back in the fiscal year 1981 and 1982 portion of the program. As we have gained experience and moved into the actuality of these years, it is apparent that we have to make major investments in areas that had been in the past, perhaps, viewed too optimistically. Additionally, new things have been added to the program, such as the Centaurs. They fall in several categories. A portion of the new investment must be for spares. We are prepared to show you, for example, how those spares build up in these next few years.

There are several other areas where the operations were, I believe again estimated too optimistically. The Centaur adds $269 million through 1988.

Mr. VOLKMER. OK. Are the program reserves being budgeted in fiscal year 1984, those for 1984, commensurate with programs scheduled and our technical risk?

General ABRAHAMSON. Yes, sir, I believe that they are.

Mr. VOLKMER. All right.

General ABRAHAMSON. Of the total R&D appropriation, we have about a 7-percent reserve; we have made it a matter of policy to try to distribute a significant portion of that reserve to the projects in the field. About 5 percent is distributed to the field and we retain about 2 percent at Headquarters.

Mr. VOLKMER. A recent Aviation Week article reported that combining DOD and NASA shuttle facility and operations costs into a separate entity is under initial evaluation at NASA. Is that correct?

General ABRAHAMSON. In my judgment, one of the problem areas that the overall shuttle program has experienced is that it has been looked at all too often, as separate Department of Defense activities, and budgeted by DOD, while the NASA portion of the program was budgeted and examined separately as well. Whether or not the Vandenberg operation belongs to the Department of Defense, it still has to be very carefully integrated into a National Space Transportation System. I believe the budgeting, the processing, and the planning have to be done on a consistent basis. That does not presume a takeover of the shuttle by the DOD or vice versa. Rather, it means that we must coordinate and look very carefully at the program, so that when a cut in one budget is made, it does not cause an adverse impact in the other budget. In the past that has happened; most notably, in the development of the IUS, changes in the NASA planning significantly impacted the cost of that program.

Mr. VOLKMER. Therefore, really the objective then is mostly for planning, and it is not to set up a separate entity or agency within the Government, combining the DOD and NASA operations into a separate operations entity, then?

General ABRAHAMSON. That is correct.

I would like to expand on that, if I might. Let me give you an example on the operational side and some of the things that we have done.

Mr. Nelson mentioned the shuttle processing contract, which is a processing or maintenance effort to insure that we have an efficient operation as well as the best talent available to get the shuttle turned around quickly. If a shuttle is launched from Kennedy and is recovered at Vandenberg Air Force Base for its next flight, it is imperative that the processing, the quality of the maintenance and the planning for the processing, be done in a similar fashion at Vandenberg Air Force Base, as is done at KSC.

In the past, Air Force planning was to have that done by a different contractor than the one that was operating at Cape Kennedy, so part of this emphasis on a National Space Transportation System has been to join those activities so that the shuttle processing contract RFP that was released in January, included an option for the Air Force at Vandenberg—this should allow the same contractor to process the shuttle at both coasts.

Now, in order to insure the separateness of both agencies' activities, while gaining the benefits of having a single contractor at both coasts, then it is important that we insure that we have proper accounting systems so that costs do not flow back between the agencies in a way that is uncontrolled. Therefore, we are trying to look at all of those things so that we do maintain the independence of the two agencies. That is an example, from an operational viewpoint, of how I believe a National Space Transportation System has to work.

Concerning the budgeting activity, we have looked at two alternatives: one is a single, integrated budget which would be developed and reviewed separately, and perhaps even fenced. That is a more extreme option, one that has implications for the way Congress is structured as well as DOD and NASA. In that event, one would have a single review of this program and then properly divide the budget between the amount that should go to DOD and the amount that should go to NASA. In this way you still maintain the separate operating entities but you make sure that the review is a singular process.

We felt that that was going too far, so we are now proceeding with ways in which the budget can be coordinated between the two agencies so that we do not get out of synchronization as priorities are imposed on the budget by each agency.

Mr. VOLKMER. Thank you very much, General Abrahamson. I have a few more questions but before I go on, I will recognize Mr. Chandler for some questions.

Mr. CHANDLER. Thank you, Mr. Chairman.

General, you may have answered this first question.

I have a series of seven, and Mr. Chairman, may I have the permission of the committee to submit these in writing for the record if we do not complete them all?

Mr. VOLKMER. You may.

Mr. CHANDLER. If you have already answered this, sir, just indicate to me. I am sorry I have not been able to be here for the whole thing.

Could you explain the contents of the NASA-DOD agreement to develop the Centaur upper stage?

General ABRAHAMSON. Yes, sir. I would like to have Mr. Weeks comment on this because he negotiated many of the elements of it, and has the oversight responsibility within my organization.

Mr. WEEKS. The NASA–DOD Centaur agreement as it now exists is, we are sharing with them on a 50-50 basis the development of the Centaur–G, which is the 20-foot version of Centaur. The additional costs that are necessary to develop it for the longer version, which is 30 feet, which is the one that we plan to use for both the Galileo mission and the ISPM mission, will be NASA's additional expense.

Mr. CHANDLER. You have answered my next question as to whether you have an agreement that defines the total cost for both NASA and DOD.

Mr. WEEKS. Yes, sir. That sharing is 50–50 of the Centaur–G development, but also in the agreement there is an agreement as to a maximum that we will ask DOD to pay. However, we consider that that is fairly carefully thought through and our requirements are sufficiently firm that we can live within that ceiling.

Mr. CHANDLER. What are the major milestones for the Centaur? Where are you presently in the program? Has your plan been modified since last year?

Mr. WEEKS. The basic modification that has happened in the last year, to catch the last one first, is to add in the two DOD launches in addition to the two launches for NASA.

The first part of your question was?

Mr. CHANDLER. The major milestones.

Mr. WEEKS. The the key milestone that really drives all of our planning deals with the pad availability. The second shuttle launch pad will be available in January 1986 for the two planetary launches. Those launches have a very narrow window, which is typical of planetary launches. We have to get off both the Galileo mission and the ISPM mission in the last half of May 1986. Those are the major requirements that drive our schedule milestones.

Mr. CHANDLER. Will you be able to launch both by May of 1986? Is that on schedule?

Mr. WEEKS. Yes, sir. That is on schedule, sir.

Mr. CHANDLER. Thank you.

General ABRAHAMSON. We should point out, sir, that is a very challenging schedule. The end event, being able to launch two of these new systems within 30 days of each other, is one that we are taking very seriously.

Mr. CHANDLER. Developing the upper stage vehicle, the Centaur, to replace another one, the inertial upper stage, for several missions, is occurring now as the Federal Government is trying to curtail spending and balance the budget. I wonder whether the Centaur duplication is necessary. I hear words such as, "The shuttle-compatible Centaur is a minor modification of the existing Centaur." If this is the case, I expect that costs and schedules should be met.

As a safeguard, however, I wonder whether one answer might not be the placement of a congressional spending cap on the NASA Centaur program to keep the development within projected cost. What would you feel about such a spending cap? What will occur if

the joint DOD-NASA Centaur development cost exceeds the planned $300 million figure?

Mr. WEEKS. Since it is quite a long list, it might be wise to put that in the record, if you don't mind, Mr. Chandler?

Mr. CHANDLER. You want to answer that in writing? All right. I would appreciate having that for the record. That is the purpose of the questions, obviously, and if we can get those to you and you could respond in writing——

Mr. WEEKS. It is a most reasonable question.

Mr. CHANDLER. All right. Thank you very much.

[The information follows.]

A Congressional spending cap at the currently projected DDT&E cost of $374.7 million for the Centaur G and G Prime would be acceptable to NASA. We believe that the program is, at this time, adequately defined such that the development can be accomplished within the indicated funding. Additional unanticipated requirements from the Department of Defense could conceivably add to the costs; however, under our agreement with the United States Air Force (USAF) such requirements will be funded by the Department of Defense and will be additive to the amounts already committed by them.

If for some unforeseen reason NASA costs should escalate beyond present estimates, NASA would expect to justify any request for additional funds to Congress, with or without a Congressionally imposed ceiling. However, each ceiling imposed on the NASA budget invites others. The sum of too many ceilings is that NASA would have little flexibility to carry out its programs and excerise ongoing management judgement, as well as adjust to changing program requirements. Therefore, NASA would prefer that Congress's intent be expressed in the authorization and appropriations process without the added limits of specific ceilings.

Mr. CHANDLER. Thank you, Mr. Chairman.

Mr. VOLKMER. That is quite all right.

I now recognize the gentleman from California, Mr. Mineta.

Mr. MINETA. Thank you very much, Mr. Chairman.

General Abrahamson and Mr. Hodge, I apologize for not having been here for your testimony. Maybe, if we have already covered these questions—oh, Mr. Hodge has not testified.

Let me ask General Abrahamson; What is the actual cost now of a shuttle launch?

General ABRAHAMSON. Of a launch itself?

Mr. MINETA. Not the user price.

General ABRAHAMSON. Yes.

Mr. MINETA. What is the cost?

General ABRAHAMSON. It is a difficult question, in that there are several ways to arrive at a solution and probably several of them are equally valid.

If you added up the total cost of the Kennedy operation, the Johnson operation that pertains to the shuttle, and the Marshall operation that pertains to the shuttle, and divided that amount now between the five launches that we have in fiscal year 1983, then added to it the cost of an expendable tank and the cost of the refurbishment, as we project it, of the solid rocket booster, we are talking between $225 and $250 million. Now I am not sure that that is the best way to get that answer, but it is one way.

Mr. MINETA. What would your estimate be, let's say, in a 1986 timeframe?

General ABRAHAMSON. In order to do it in the same way, adding it up that way, I would have to supply that for the record. However, we do have a defined accounting system where we have includ-

ed costs that we believe are really the ones that should be laid out for the cost-per-flight accounting for the future as we go ahead.

Unfortunately, our accounting is in a different way. Let me give you one number: In the past, we have tried to calculate this over a 12-year average, which I am not sure is a valid way to do that but it is one that the committee has seen. Our calculations now for that 12-year average is some $57 million, but that is in 1975 dollars and over that 12 years, if you would double it you would probably be there in current dollars.

Mr. MINETA. Oh, for the good old days.

General ABRAHAMSON. Yes, sir.

[The information follows:]

NASA estimated that the total operations cost perflight for the 17 anticipated flights in fiscal year 1986 is approximately an average of $145 million per flight ($62.4 million fiscal year 1975 dollars). This figure includes the total costs for consumables, launch operations, flight operations, network support and all associated R&PM costs.

Mr. MINETA. Now as the commercial satellite companies increase their need for access to space, it appears that they are taking the course of multiple booking on shuttle and ELV's. I am wondering, how will this be accomplished for satellites larger than the launch capability of the Delta ELV, and what will NASA provide?

General ABRAHAMSON. You may find a chart on the amount of double booking that we have now instructive, sir.

Meanwhile, let me go ahead and try to answer the question. At this point in time, many of the satellites that we are putting up were initially designed to go on ELV's. Therefore, the additional expense is one to make them compatible for the shuttle and safe for shuttle operations. In fact, that has been a detriment to bringing people on to the shuttle because they had to make additional investment to do that.

However, because customers felt that the shuttle does represent a new technology, and launch date is one of the most important factors that a commercial customer would look at, quite a few people did double book. Here you can see some of those (fig. 6). You can see the ones that are shuttle only, some of those that are double booked on shuttle, and some that are ELV only, itself. Of course, some of them are triple booked as well as with the Ariane.

As I say, this is not a significant problem now and most of these satellites are within the capability of the Delta. Therefore, it is possible, for example, to take an Intelsat from our eighth mission and, with some lead time involved, schedule it on a Delta and successfully launch it. As the payloads get larger, as you have justly pointed out, they will be taking advantage of the shuttle. In fact, they will quickly leave the realm in which designers have available a good option. An example of that which is in development now, is Intelsat 6. This will be a very large, very sophisticated communications satellite and we are bidding for it right now. It will be compatible with the shuttle, but it would take an improved Atlas Centaur to provide a backup. It could use a Titan to provide a backup or it could use a future version of the Ariane to provide that backup, but all of those are reaching somewhere near the limit that those particular ELV's offer. If you get much larger, you will no longer be able to do that.

Therefore, in the end, what has to happen is that the shuttle, itself, I believe, must be the backup. It must be reliable enough so that designers will feel confidence that they can go ahead to take full advantage of the shuttle and the cost savings that they will be able to implement. We cannot continue to carry infinitely into the future backups, and maintain multiple fleets of booster capability.

Mr. MINETA. I'm sorry. You said a shuttle backup——

General ABRAHAMSON. Yes, sir.

Mr. MINETA [continuing]. A shuttle backup to a shuttle?

General ABRAHAMSON. Yes, sir. The way you do that is to insure that you have sufficient depth in the shuttle fleet and some openings in the manifest, so that if a problem develops, then you can just shift the payload downstream to another shuttle.

Mr. MINETA. Then are you going after the fifth orbiter?

General ABRAHAMSON. No, sir. We have at this point a compromise that we think is a reasonable compromise and a good one for now. One that maintains that option for the future, but at this point in time we do not feel that the overall projection of demand out after 1988 is firm enough that we could justify the fifth orbiter in the light of the overall national priorities that are being dealt with at this point in time. Now, that was a compromise and one that was difficult; but, it was the judgment of the administration.

Mr. MINETA. Are you planning to compete with Ariane?

General ABRAHAMSON. In deadly earnest, sir.

I might point out, the Ariane does not have a backup to the Ariane.

Mr. MINETA. Now if the spacelab is bumped from the shuttle, how will the European spacelab then be accomplished?

General ABRAHAMSON. Are you referring to our first spacelab launch, STS–9, sir, or in general?

Mr. MINETA. Right. Let's say for—I don't know—national security reasons, the spacelab gets bumped.

General ABRAHAMSON. It would be rescheduled. As we were running into this particular launch problem due to the delay of STS–6, we made a major effort to try to see if we can maintain the spacelab launch schedule. I will go back to show you just how far we have gone.

We did not do a full modification of the *Columbia* so that we could, indeed, accomplish the space lab mission on time to meet the science objective which is best met in a narrow launch window at the end of September. Therefore, we made a major effort to do that in spite of the fact that that was a difficult proposition. Nonetheless, this was the basis for our partial modification decision on the *Columbia.*

Now, with our launch delay, we are in some trouble—that is very clear. We are going to have difficulty maintaining the September space lab launch but we think it is still within our grasp. There are two backup options. We will be able to launch the space lab on September 30, because we are launching on a different shuttle, the *Columbia.* Our problem is not the shuttle or launching it. The problem is getting two TDRSS spacecraft up prior to the space lab mission in order to maximize the science return.

We have looked at different options. We could delay the space lab as far as December or even next February, but that is not very

desirable from the European viewpoint. They would rather launch the space lab on September 30, on time, with two TDRSS's. If they cannot do that, they would accept launching it with one TDRSS, providing we can minimize the data loss through on-board recording, and we are building a plan to do that.

Therefore, at this point we have no intention of slipping the space lab launch. If we did slip—and your question implied a concern with the DOD priority—there is a DOD launch scheduled, STS 10, in early November, which is just a little over 30 days from the space lab launch. If for any reason we were forced to slip, I believe we would have to jump over that launch. It is less desirable from a science viewpoint, but it could be accommodated.

Mr. MINETA. In a June 14, 1982 letter to the NASA Administrator, Mr. Stockman anticipated that during the 1986–88 time period, shuttle operations would be on the basis of additive costs for commercial users. However, Mr. Stockman also expected that subsequent price of excess capacity to commercial and foreign users will be on a full-cost basis. What is NASA doing to relieve the general taxpayer of the burden of subsidizing commercial and foreign government flights in the shuttle, and how soon do you think this might be accomplished?

General ABRAHAMSON. I believe, sir, that that is an unresolved issue, and I would like to answer that for the record.

Mr. MINETA. Mr. Chairman, I do not believe I have any further questions at this time. I yield back the balance of my time. I appreciate the generous 5 minutes that you gave me.

Mr. VOLKMER. I think the 5 minutes have probably elapsed, anyway.

I now recognize the other gentleman from California, Mr. Brown.

Mr. BROWN. I would like to discuss with you briefly the program that you have described under advanced programs, which includes the planning for a space station and some related activities, all of which seem to be reasonably related to a space station. It looks like the advanced program item might be described as a space station item. Is that roughly correct?

General ABRAHAMSON. Sir, we have some prepared testimony by Mr. Hodge, who is the director of our Space Station Task Force, and who will discuss that later. However, we can answer your question now, but, I would like to ask Mr. Hodge to address those issues or you could ask the questions after his testimony, whichever you would prefer, sir.

Mr. BROWN. Well, let's withdraw that question. It isn't really important, anyway. I recognize that he will offer testimony on that later but I would like to get your views to some degree, based on the testimony that you have offered.

There are $15 million for the advanced programs plus $3.3 million for the Tethered Satellite System.

General ABRAHAMSON. Yes, sir.

Mr. BROWN. My general understanding is that as far as the space station is concerned, you have no authority to proceed with anything further than what you might call a conceptual definition at this point. Is that correct?

General ABRAHAMSON. Yes, sir. We are doing, essentially, mission analysis studies and some technology work. This limit in 1984

of $6 million as submitted in the budget does represent the conceptual studies primarily, as well as some very specific technology work. There is other technology work which is going on in the agency under other line items which will be broadly applicable to not only the space station but other space activities as well.

Mr. BROWN. I am looking at what you call the investigation of systems, tools, and techniques for placement, retrieval, and maintenance, repairs of spacecraft. That would be applicable on a dual basis, I presume?

General ABRAHAMSON. Yes, sir, it would be.

Mr. BROWN. The definition of advanced transportation vehicle concepts, including orbital transfer vehicles and shuttle-derived vehicles, that would be applicable, generally speaking, to both the space station concept and other activities?

General ABRAHAMSON. Sir, they would not necessarily be the space station or included in a space station project, but they would certainly be vehicles which would be complimentary to an overall national system that would supply and work with a space station.

Mr. BROWN. It seems to me that, looking at our problems with advanced communications satellites, that we are moving—and I don't know how fast—but in some ways we are moving toward larger systems which have sometimes been described as antenna farms in space, using next-generation technologies of various different kinds. The question that comes to my mind is, How much different are the kinds of studies that you are making for a space station from the kinds of studies that might be involved in looking down the road 10 or 15 years for very large-scale communications satellites in geostationary orbit? Are there certain areas of commonality there?

General ABRAHAMSON. Sir, I am going to ask Mr. Hodge if he would like to address that, principally, because we are really in a very architectural mode on the space station. We are just looking at how space stations should be structured, and we are trying not to get to a self-limiting definition of the program too early.

Here is an example of a small step toward one of the antenna farms (fig. 7). This is the TDRSS satellite mounted on the IUS. This particular combination is now sitting in the shuttle waiting patiently for our sixth launch. This TDRSS satellite is the most complex communications satellite produced to date.

John, would you like to comment.

Mr. HODGE. We are at the moment looking at all of the potential requirements that might appear in the timeframe 1990 to 2000. One of the missions which is coming out of that is the very large antenna system. In general, that mission will probably require more than one shuttle payload to erect it.

In the context of the space station, we are examining whether it is better to do it with two shuttle payloads and then build it in such a way that you can construct it in the 7-day period you have on the shuttle, or whether there are advantages to having a man permanentaly in orbit in order to either reduce the cost or take better advantage of that. That is one of many missions.

Mr. BROWN. You are looking at these various missions.

Mr. HODGE. Yes.

Mr. BROWN. The point that I am trying to get at, if there is a point, is that you have already defined, missions already fairly clearly in prospect such as a large communications satellite activity. The space station you are looking at more from the standpoint of, we will say, a general utility structure, I presume.

Mr. HODGE. Yes.

Mr. BROWN. You are looking for missions, scientific, technological, military, other missions that might appropriately fit into it. What I am trying to visualize in my own mind is whether these two lines of analysis converge at some point and there might be some factors which would have a bearing upon the timing with which we move forward on some of these projects.

Mr. HODGE. The whole purpose of our mission analysis studies right now is precisely to bring along that convergence that you are talking about, as well as the examination of those in the context of the various ways to perform missions.

As we see things at the moment, either the shuttle or the space station will be in low-Earth orbit. In order to get those missions in, we have to have a high energy upper stage of some kind. What we are looking at is the cost tradeoffs between the various ways of doing it. We are trying to determine whether any particular mission is enabled by a space station, or whether the efficiency of its operation is increased by a space station. That is the type of aspects which we are reviewing to determine if there is a need for one or not.

Mr. BROWN. However, you are looking at space stations in both low-Earth orbit and higher Earth orbit?

Mr. HODGE. No, sir, not at the moment.

Mr. BROWN. Just the low-Earth orbit?

Mr. HODGE. One can envision in the long term—timeframes beyond the year 2000—that manned facilities, either permanent or temporary, in geosynchronous orbit, would be required, but they do not appear to be coming out of something that we should be considering in the next 15 years.

Mr. BROWN. I do not want to prematurely move into your testimony. I was trying to get to the general picture that might be pertinent here. Fundamentally, I am concerned about whether the level of authorization at $15 million provides the proper assurance that this program will be able to move ahead on a time schedule which would be in accordance with the needs of the country and the posture of the United States in this field.

In other words, if we wanted to step this program up, instead of planning a 20-year program that would result in development in the decade of the nineties—assume we wanted to move it up 5 years—what would be the effect on this year's budget item for advanced programs? Would you be in a position to speculate on that?

Mr. HODGE. We have looked very carefully at the level of funding that we think we need in order to meet a potential initial operating capability in the period 1991. It would be possible to increase the rate of doing that but I am not sure that it would be proper to do so. I think it is very important that we look at these mission requirements as they develop in a rational way and do a very clear definition before we commit to hardware. In this kind of a program, which is so broad and covers so many possibilities, it would

be unwise to move ahead before we had a clear understanding of specific functions we wanted to perform. I believe that the $6 million of the $15 million that we have in the advanced programs is adequate for the 1984 budget.

Mr. BROWN. Thank you.

That is all, Mr. Chairman.

Mr. VOLKMER. Thank you, Mr. Brown.

I now recognize the gentleman from New Mexico, Mr. Lujan.

Mr. LUJAN. Thank you, Mr. Chairman.

General, I am sorry I was late. We had the western Governors' meeting at noon, but I would have enjoyed being here for the discussion on the engine figures. We were, of course, fortunate in being there over the weekend while the action was going on, even to the point of watching until they got through boroscoping one of the engines to see how it came out. So, our chairman got to know them very intimately, almost on a first-name basis. No, it was a last-name basis because, instead of calling them 2011, he was just referring to them as 11 and 15 and 18. So we got pretty friendly with them.

One thing that I have wondered about is why we take the solid rocket booster and save that but we do not save the external tanks. Let me talk some numbers with you: Not counting the fuel, how much does it cost to build the solid rocket boosters?

General ABRAHAMSON. The solid rocket booster?

Mr. LUJAN. Not counting the fuel.

General ABRAHAMSON. Yes, sir.

Mr. LUJAN. Well, how much totally, with the fuel and everything? I am trying to get the difference between what it costs to have a brand new one and what it costs to have a refurbished one, just generally.

General ABRAHAMSON. Sir, our problem there is that we have never looked at it without the fuel.

Mr. LUJAN. OK, with the fuel.

General ABRAHAMSON. However, with the fuel, as we are buying a new set at this point in time—and recognize we are quite high on the learning curve—it is approximately $64 million.

Mr. LUJAN. That is $64 million for a set of the solid rocket boosters?

General ABRAHAMSON. Yes, sir. That is for a set of two new solid rocket boosters, which are scheduled to be delivered this year.

Our costs now—which again I consider excessive, and which we have plans to reduce very aggressively—to refurbish a set and then to put that up, and again including fuel, is approximately $25 million, so you see we get a very major reduction by saving those solid rocket boosters. We believe that we can reduce that cost substantially in the future when we have the design fixed in such a way that we do not have significant damage on each flight.

Mr. LUJAN. Oh, yes, I understand that. What about the external tank? What is the cost of the whole external tank?

General ABRAHAMSON. The external tank is between $35 and $40 million, at this point in time—and again, remember we are in a high part of the learning curve—and without fuel.

Mr. LUJAN. That is without fuel?

General ABRAHAMSON. Yes, sir.

Mr. LUJAN. Yet I do not understand why we do not—maybe it is an impossibility—why don't we try to salvage the external tank?

General ABRAHAMSON. Very early in the program, in fact the first few years of the program were spent—and I am just now going from hearsay and from a distant relationship to the program, since I was not there in that timeframe—they spent a great deal of time doing cost tradeoffs, looking at those various options and looking at what is really technically achievable. After a series of those cost tradeoffs, they came to this particular judgment, and it is worthwhile to go back and reask some of those questions.

However, we have not gone back and said, "Should we now look again to see, can we fly the external tank back?" In a sense, that tank is another kind of a shuttle—really, an unmanned shuttle with wings—that you would have to fly back because it is a very light structure. As it could only handle very low heating loads, it would have to be brought back very carefully, perhaps by parachute with some large heat sink that you would then throw away.

All of these configurations were reviewed. I can only say that the judgment at that point in time, projecting the economics ahead, was that this is the best way to configure the vehicle.

Mr. LUJAN. Therefore, it was determined that you are better off not salvaging it.

General ABRAHAMSON. Yes. Obviously, again, it could be reexamined; but, we have kind of put our heads down, and we have been just charging, trying to make our existing system work at this point in time.

Mr. LUJAN. You got into a little discussion about the Ariane a little while ago and you said, "Well, there is no backup to the Ariane." Well, there isn't, is there?

General ABRAHAMSON. They took a few of our payloads, so they are there. In fact, I think it is a professional team that we have to deal with and we have to deal with them professionally. I think in our competition we have to assume that they will be successful.

However, they have a specialized vehicle without the growth potential that the shuttle offers in many ways in the future. In the end, there is a very important kind of historical, inevitable trend that will bring customers to the shuttle; and, that the Ariane and the expendable launch vehicles, if they serve a purpose at all, will be kind of on the fringe as very specialized vehicles.

Mr. LUJAN. I do not quite understand why they are our competition. It is not manned; it is not a shuttle. Do I understand that correctly?

General ABRAHAMSON. That is correct.

Mr. LUJAN. What is it? Like we used for Apollo, or what kind of a vehicle is it?

General ABRAHAMSON. At this point the Ariane 1, the first version, which this is the one that they have flown successfully, also had some problems. It is more or less equivalent to our Delta expendable launch vehicle, which is capable of putting up a single communications satellite of the same basic size that we put up——

Mr. LUJAN. That is a rocket you are talking about.

General ABRAHAMSON. Yes, sir.

Mr. LUJAN. We have rockets that shoot up our shuttle. We are talking about what carries them, or are they going to launch them just like we used to launch in the past?

General ABRAHAMSON. Yes, sir. In fact, the Ariane in terms of technology is quite similar to our Delta technologies. In fact, at the time that we lost some of the initial U.S. customers to the Ariane, I believe that technology was one of the factors. People felt that because it is an old technology it would develop rather quickly and would not have a large number of problems.

Mr. LUJAN. Do we kind of feel like that is an old-fashioned thing? Could we launch one right now with expendable launch vehicles, but feel that is just old-fashioned stuff, so we are going to use the shuttle from now on? Is that what I am seeing here?

General ABRAHAMSON. As I say, I think the wave of the future is the shuttle because it has substantially increased capability that the Ariane or an expendable does not. However, yes, today we can launch a payload in a fairly quick time on one of these expendable launch vehicles, if the vehicle is built and standing by. Of course, we are helping our European friends by doing that now. The Europeans have announced that we will be assisting them by bringing one of the payloads that was scheduled to go on the Ariane—the Exosat—back to the Delta. We will put it up with a Delta in the May timeframe. We are doing that fairly rapidly.

Perhaps I am misunderstanding what you are driving at, sir.

Mr. LUJAN. Well, what I am driving at is, we look at the Ariane as our competition to the shuttle, and I fail to understand that. I understand exactly now what the Ariane is. I originally thought—before this trip, as a matter of fact, because Mr. Weeks explained to me—I thought it was another shuttle, another vehicle just like we are developing.

General ABRAHAMSON. No, sir. The only other country in the world that, at least, has publicly admitted that they are developing a shuttle is Russia.

Mr. LUJAN. Let me ask you, can you give us a comparison between us and the Soviet's ability to resupply manned or unmanned spacecraft?

General ABRAHAMSON. The Soviet Union has had a very active program where they have been launching, over the last few years, a total, I think, of about five times the number of satellites as we have. When I say total, that is total military and scientific and applications satellites over what we do.

Part of that program has been a very active program with a Soviet interim space station. The first manned one was called Salyut 1. Salyut 6 was put up in September 1977. They now have Salyut 7 in space. They use an expendable system, a workhorse, to go up and resupply those interim space stations. They call this resupply vehicle the Progress which is capable of going up automatically, rendezvousing, and docking, or it can go up in a manned mode to take astronauts up and down as well as cargo. There were six Progress flights to Salyut 6.

They have been very, very active. I would like to supply some additional information on the number of manned launches, the number of man-days in the air that the Soviets have had, compared to the United States. It is an impressive comparison in their

favor, so they are getting a great deal of manned experience. They are getting it primarily in the area of operating in a space station environment, and clearly in experimenting with both military and scientific and applications missions in that activity.

Because we were waiting for the shuttle to develop, we got badly behind in manned experience. The only space station activity we had was the skylab, which was a temporary capability. Our missions now are short; however, we are now beginning to rapidly catch up with what we think is very comparable and very important manned experience for the future. It is not space station experience, however.

Therefore, interestingly enough, the Russians and the United States have taken two separate directions. The United States initially looked at where they would go in space with a task force, the Space Task Force, in 1969. The shuttle was elected to be built first, with a space station following. The Russians looked at the same problem and elected to build a space station first, assuming that a shuttle would follow. That is what they are doing now, they are starting their shuttle program.

Mr. LUJAN. What is the difference between their Salyut 6 and 7 and our skylab?

General ABRAHAMSON. The skylab was a scientific mission. It did have such things as astronomy missions and some Earth resources activities, but it was also aimed at getting information on human performance in space. We obtained some very dramatic data points when the skylab itself malfunctioned and our astronauts were able to go up on very short notice to effect a repair, demonstrating that man does have a very important function in space that automatic spacecraft do not have and cannot have. I think there are a group of us who strongly believe that; but that opinion is not shared by everybody.

Mr. LUJAN. I am trying to get a comparison between skylab and Salyut 6 and 7.

General ABRAHAMSON. Yes, sir. Salyut 6 and Salyut 7, as I indicated, did have Earth resources activities and did have material processing in space; experiments which the Russians have talked about that. In addition to that, it had a military mission which we do not know a great deal about. However, we do know that for very significant periods of time, the Salyut 6 and Salyut 7 were dedicated to military missions of some kind, so they are getting additional experience in that area that we have not been able to gain.

Mr. LUJAN. They have done materials work?

General ABRAHAMSON. Yes, sir.

Mr. LUJAN. Medicine?

General ABRAHAMSON. We are not aware that they have done anything as advanced as the McDonnell Douglas electrophoresis experiments that were conducted on STS-4. We do know that they have done some electrophoresis kinds of things. Their material processing, that we are aware of, was aimed at growing crystals, which were things that we also tried in skylab.

Mr. LUJAN. Thank you.

Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you, Mr. Lujan.

I will now recognize Mr. Lowery.

Mr. LOWERY. Thank you, Mr. Chairman.

General, congratulations on your new star.

General ABRAHAMSON. Thank you, sir.

Mr. LOWERY. That is quite an accomplishment. I am looking forward to working with you these next 2 years, to continue where we have been in the last couple.

If I could just try to respond to my colleague from New Mexico's question, I would say we are kind of in a space travel transition, with our expendable launch vehicles and the shuttle. If there is an analogy that could be drawn, I guess it would be to horse-drawn power and the internal combustion engine, going back about 80 years or so.

The competition we face from Ariane is primarily on price at this point, but we have so much more vast potential. They can handle the smaller payloads somewhat competitively now but I think the vast potential for the future, which we are going to do with this truck, is phenomenal. Again, carrying on the analogy to farming, some farming is still done by horse-drawn plow or wagon—there is some of that in your district—but so much of it is done mechanically.

Mr. WALKER. There is quite a bit in my district, yes, good farming, too.

Mr. LOWERY. So much of it now is mechanized because of the internal combustion engine. Therefore, I am just ecstatic about the future.

General ABRAHAMSON. Thank you, sir. You put that very eloquently.

Mr. LOWERY. General, how do you feel about a single national space transportation budget that would combine NASA and DOD funding requirements for the shuttle system?

General ABRAHAMSON. I did comment on that earlier, sir. I believe that the important objective must be a coordinated budget. We have been looking at two options for that. We felt that going so far as a single budget, dedicated and fenced, is probably beyond the capability of the various bureaucracies involved now, and a very difficult step. So, we are proceeding with careful coordination between the Department of Defense and NASA to insure that we have our priorities equally layed out for the programs.

Mr. LOWERY. I know there is a great deal of coordination that takes place, and a lot of that comes together at the executive branch. About the only place is really at OMB. Here in the Congress it does not necessarily come together, either through the authorizing or the appropriating process, so does it not make a bit more sense to look at it on a more unified basis? I realize there has been a good deal of coordination but from a budgetary standpoint, if it were unified and combined, might we get even better efficiency?

General ABRAHAMSON. I believe that there are those kinds of desirable outcomes but, very difficult to achieve. That is why we have done some initial studies with that as an objective.

Mr. LOWERY. If it were to come about, who should be in charge?

General ABRAHAMSON. We have not answered that. There were some very careful studies about where ultimate shuttle operations responsibility should be that preceded the President's space policy

that he announced on July 4, 1982. This study did not concentrate just on the budget, but at the entire operational problem of where should the shuttle reside as a system. The conclusion was that for the present there are merits in having it located in different locations.

Clearly, there is merit in having NASA have the total responsibility. There are different advantages having DOD have the total responsibility, and there are even some advantages to having a new agency or a commercial enterprise run the shuttle program. However, the final conclusion of that study was that it is premature to make that judgment at this point in time. In general the shuttle had to develop further as an operational system, before that decision can be made. Therefore, the direction that came out of this study was that we should implement the operational shuttle program in a very careful way so as not to preclude going in any one of these particular directions in the future. We are proceeding in that way.

Mr. LOWERY. What about a space transportation clearinghouse set up within Government for shuttle missions?

General ABRAHAMSON. Could you explain what you mean by that a little better?

Mr. LOWERY. Well, obviously there are going to be conflicts in the future, and right now I know there has been a good deal of discussion that the national security missions would have priority, but when it becomes somewhat crowded with commercial research, Defense, NASA missions, how is all that going to be sorted out. Should there not be some kind of a formalized method for doing such?

General ABRAHAMSON. A long time ago, I was the director of the F-16 program, and we had a terrible strike that just crippled the F-16. There was a set of priority decisions that had to be made between delivering engines to the F-16 and the F-15 for the U.S. Air Force, but also delivering engines for F-16's that were going to Israel and to four of our European partner nations.

It was pretty clear to me, at least, as the program director in those days, that that kind of a decision on how the priorities should be resolved required detailed information that was beyond the ability of the higher levels of the bureaucracy to manage on a day-to-day basis. Therefore, the way we approached it, was to set up priority rules which the bureaucracy agreed to. Once those rules were straightened out we turned it over to the operators who could then manage the complexity of the program to make it work.

I believe in the end, sir, that that is a good model; that there are a set of rules that can be established and should represent national policy, and provide guidance to day-to-day managers, who are required to work the problem out. In fact, my judgment is that for a substantial period of time, national security conflicts with other missions will not be a major problem. Usually we can see a slip or a problem coming months ahead of time. As a result, we have the ability to react to it. If we build our manifest properly, with margin in it, I believe that we can deal with those things and not have DOD priority missions really impact, in a significant way, commercial payloads or scientific payloads that are important to our future in space.

However, what it requires is some artful, day-to-day manifesting and some ability to get out and push one or another part of the operation in order to make the schedule work. That is why, if I understand what you are saying about a clearinghouse, I have a concern. I think the responsibility must be in the realm of the operators; but, it is absolutely appropriate that, as a policy matter, the Executive and the Congress should agree on the priorities for the various categories of missions.

Mr. LOWERY. Finally, a parochial California question, if I might ask—and I know it is just being administered by the Air Force—but what is the progress being made for shuttle facilities at Vandenberg?

General ABRAHAMSON. I think we are making much better progress than was being accomplished a year or so ago when the slip developed at Vandenberg AFB. The Air Force testimony that will be made to some of the other committees is one that says they feel that they can make the October 1985 launch date. That does not mean there are no problems; there are some. NASA and the Air Force are working together to try to resolve those problems. Nonetheless, the general conclusion is that October 1985 is still a doable milestone for an initial shuttle capability at Vandenberg.

Mr. LOWERY. Could you highlight a couple of those major problems?

General ABRAHAMSON. One we are working on at this point in time is having our filament-wound case, which is a NASA development responsibility, developed early enough and in such a way that it will meet the interface needs of the launch pad at Vandenberg. That pad is structurally stiffer than the one we have at KSC, so we have a different dynamic problem. We are working on that right now. That is a very esoteric problem but it is an example of the kind that we deal with.

Mr. LOWERY. Are there other major problems you are having?

General ABRAHAMSON. Not major ones. There is a concern with ice protection at Vandenberg Air Force Base. That will not be a significant operational factor so long as the launch rates are low. They can just wait a few days if they get icing conditions. However, in the future when launch rates do become higher, then they will probably have to have a more efficient icing protection system. There are studies that are being made on that now.

Mr. LOWERY. Is that related to the wind situation, the icing?

General ABRAHAMSON. Yes, sir. It is a combination of winds and moisture at Vandenberg Air Force Base, which tends to develop more hazardous sheet icing that gets all over the cold external tank. That is not a major problem at Cape Kennedy.

Mr. LOWERY. Is that able to be shielded, wind shields?

General ABRAHAMSON. There are several approaches to it. One is blowing hot air, and we are working with the design for them now.

Mr. LOWERY. Are there other approaches you are looking at besides these?

General ABRAHAMSON. Yes.

Mr. LOWERY. OK. Is there shielding, a wind shield——

General ABRAHAMSON. There is a large wind shield that is being made, not for the purpose of preventing ice; but, because the plan initially was deficient in the general area of atmospheric protec-

tion. The mating of the orbiter to the stack on the pad, which is a different operation at Vandenberg, is a very critical procedure. We made a judgment that you just cannot do that out in the wind and the weather, so there is a large windshield that is being built for that purpose.

Mr. LOWERY. Thank you, General.

Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you very much.

I have a couple of other questions, General, that I would like to ask. One has to do with the overall cost and trying to get away from cost-plus. Can you elaborate—if you would rather do it in writing, you can do so—but can you elaborate on what NASA is doing to increase productivity and decrease costs through the use of contract incentives, to maybe get away from cost-plus and use either cost-incentive or fixed-price contracts?

General ABRAHAMSON. Yes, sir. There are several levels of programs to reduce costs. One is a productivity program, and you saw some examples of that at the Marshall Space Flight Center. Those are, in fact, very important initiatives on our part. We really foresee some very large paybacks and appropriate investments for the taxpayer because of the payback ratio. However, since you have seen those examples, let me deal with cost-incentive contracting on the program. During the development phase, I believe that the cost-plus award fee contracts which we have used on all of the major elements in the shuttle program were really quite appropriate. However, we are now shifting over toward cost-plus-incentive fee types of contracts in a very major way, and that is one of our important cost savings initiatives.

We feel that if the contractor can predict exactly what his payback will be, as an incentive contract allows, that he will work hard to do that. Of course, we have to design our contract incentive appropriately. We have already converted the external tank and the solid rocket boosters, which are high-cost, recurring-cost items, so that is important.

At Cape Kennedy, we have two large processing type of contracts that are already being implemented. The first one has been completed, where we put together 14 support contracts in what we call a base operations contract [BOC]. Those were all, previously, small award fee, cost-plus kinds of contracts. They are now combined into a single, incentive fee-type of structure, and while I am not at liberty to disclose the source selection information, let me say that all of the bids for this contract had cost savings that exceeded 20 percent cost savings over and above the level of effort we are presently experiencing. Even though they are cost-reimbursement contracts, the incentive feature we think is strong enough that it means that those bids represented realistic costs. So, we feel this is an important initiative.

In addition to the BOC contract, we have let the RFP on a much larger, about a $300 million a year effort, which is the shuttle processing contract. There are two teams that are bidding for that contract. We anticipate that we will achieve significant cost savings there, and those will be incentive contracts as well.

Further, we are now looking at a similar consolidation at the Johnson Space Flight Center. It is still in the planning stage, but

we are looking at a similar consolidation of operations contracts, which I anticipate will be a cost-incentive contract.

Therefore, I believe we are making an important initiative to convert these kinds of contracts to incentive contracts, and I think we have already made a great deal of progress.

Mr. VOLKMER. All right. The next question has to do with DOD's use of the shuttle. As I understand it, they had originally contracted payloads for 1984 and 1985 and they have cancelled some of those. Is that correct?

General ABRAHAMSON. That is correct, sir.

Mr. VOLKMER. How does that impact on, one, the reimbursable funding for 1983 and 1984 by DOD? That undoubtedly must reduce it to some extent.

General ABRAHAMSON. Yes, sir.

Figure 8 depicts our initial pricing period for fiscal years 1983, 1984, and 1985, and this is clearly our loss leader period. This does show what has happened to some of the payloads that NASA thought would be there, when looked at from approximately 1981 forward.

Several things have happened. NASA has reduced the manifest down to what we think is a realistic buildup rate, and in that process, for example, we now have five launches in fiscal year 1983. Previously, we had considered eight launches. In the process of the reduction, several of the payloads were lost, some to Ariane. For example, two of the Intelsat 5 versions went to the Ariane launch system. One of the DOD launches went to a Titan when the STS operational date was delayed, and another one was postponed to fiscal year 1985. The other two—because they had a schedule problem, the Intelsat and the RCA-D—went to the Delta. Therefore, you can see specifically what happened to the 1981 launch projections.

What you see regarding DOD launches is a pattern of slips to the right. If these slips happen early enough so that it is possible to reschedule commercial payloads, or in some cases NASA payloads into those slots, what happens is that DOD overscheduling has initially offered an advantage to other users. There is now room for some of the latecomers to be manifested. That is what we are trying to do, to fill up these open slots.

However, if DOD or any user moves late in the whole process, then we are in trouble because there is not time enough to bring new ones in to replace the lost payload.

Mr. VOLKMER. It is too late to move some other payload into 1985.

General ABRAHAMSON. Oh, no, sir, absolutely not.

Mr. VOLKMER. It isn't?

General ABRAHAMSON. We are bringing on new customers and figure 9 will give you a view of that.

Mr. VOLKMER. I thought we had about a 3-year timeframe, from the time you contracted to the time you went up?

General ABRAHAMSON. There is a 3-year timeframe for new payloads, but we are being very active salesmen and trying to move payloads in development onto the STS. Earlier I said that we are in deadly earnest in our competition with the Ariane, and I assure you we are. Through last fall and up through this period, we have

brought on several new satellite systems. Let me give you one of them as a perfect example. I led a team that went to Australia, and Australia has booked on the shuttle because one of the important selling points offered them a launch for two satellites in that 1985 timeframe. We could offer them that because some of those DOD flights had moved out.

Mexico, while it is a little later, also is being filled in. We visited GTE and offered them what we thought was an attractive shuttle schedule and a package in combination with McDonnell-Douglas, and were able to bring their GSTAR C back to the shuttle, even though their A and B versions of their satellites went to Ariane and normally the pattern would be that they would continue the series with Ariane. Therefore, you can see we are bringing back customers and filling those particular payload open slots.

We are also discussing now with some additional customers to see if we can bring them back to the shuttle. So, at this point in time, we have not lost all of those open missions. However, we do have some manifest slots that we are holding open as a reflight possibility. For example, I am holding open one mission in fiscal year 1984 and one mission in 1985, and trying to schedule to fill in around those missions. What this allows is a backup flight vehicle—you remember I said the shuttle should be the backup to the shuttle—if some of our earlier missions have problems. By keeping a mission completely open and for some reason we do not have to use it as a backup vehicle, we will not have the expense of flying the vehicle.

Therefore, at this point in time we are still working and will always have scheduling problems. However, this underscores one of the important things in our agreement between NASA and the Department of Defense. If the DOD changes a mission and slips out within 2 years of the launch time, and they do that in order to reduce their budget or at congressional direction from another committee to reduce the budget, then NASA is faced with a reimbursement budget which is unpredictable. Therefore, one of the very important elements in our agreement between the Department of Defense and NASA is that if they do make a change within 2 years of a launch, they maintain the funding profile. In this way, NASA has a predictable budget, and that is very important.

Mr. VOLKMER. Is that then applied to a future payload?

General ABRAHAMSON. Yes, sir.

Mr. VOLKMER. Therefore, then you would not have to increase your budget request as a result of those terminations.

General ABRAHAMSON. That is correct, sir. Now when we lose a commercial customer's payload, we have a similar problem. However, to counteract that we have financial penalties that we apply.

Mr. VOLKMER. However, for fiscal year 1984, then, you have not had to increase your budget as a result of any DOD losses.

General ABRAHAMSON. That is correct.

Mr. VOLKMER. OK.

Mr. LUJAN. Do you have a "take or pay" contract?

General ABRAHAMSON. I am sorry. You mean we have commercial——

Mr. LUJAN. Do you have a "take or pay" contract with the Air Force?

Mr. VOLKMER. You don't have a "take or pay."

General ABRAHAMSON. With the Air Force?

Mr. LUJAN. With the Department of Defense, is that what you have, "take or pay"?

General ABRAHAMSON. If they moved from fiscal year 1984 into fiscal year 1985, let's say—they have to maintain the fiscal year 1984 payments to us in order to keep our budget constant. We do not charge them again for the launch in fiscal year 1985, on the assumption that we will have time to come back to the Congress to make adjustments either in the DOD budget or in the NASA budget to accommodate that transfer payment. However, we are not faced with a budget change after you have enacted the law.

Mr. VOLKMER. All right, now. I would like to get on. In an August 1982 letter from NASA to the Congress, the NASA Administrator noted that the Air Force would transfer funds to NASA for the purchase of orbiter spares after successful completion of the sixth shuttle mission, which is coming up. Now is this commitment still available?

General ABRAHAMSON. No, sir, I am sorry to say that it is not. What has happened between that point in time and today is that the DOD has had additional costs associated with their portion of the space program. With the termination of the Titans, they are now faced with more defined termination costs at a higher level than they had previously expected and they have had to withdraw that offer.

Mr. VOLKMER. Now our 1984 budget, your budget request, includes funds for orbiter spares.

General ABRAHAMSON. Yes, sir.

Mr. VOLKMER. How much funding did NASA request from OMB for OV-105?

General ABRAHAMSON. Sir, we requested $200 million from the administration.

Mr. VOLKMER. That would have been sufficient to start 105?

General ABRAHAMSON. We felt that that was a reasonable cost profile to start OV-105 and have a delivery date very late in the 1988 timeframe.

Mr. VOLKMER. Of this amount, how much is now included in the 1984 budget for spares, orbiter spares?

General ABRAHAMSON. I think a chart can best show the way we are really attacking the flight spares problem.

Mr. VOLKMER. I mean, we got thumbs turned down on 105 and it went to spares.

General ABRAHAMSON. Yes, sir.

Figures 10 shows the total spares budget. You can see we are dramatically increasing spares from the rather meager expenditures that were made out in the 1981 timeframe. The program has been criticized for using the amount of money for spares as a management reserve, and in fact it was forced to do that kind of thing in earlier times, but now you can see rather dramatic increases. I have tried to break them out into orbiter, engine, avionics, and other minor spares.

There is $100 million in fiscal year 1984 for the initiation of the structural spares program. That is over and above what would have been our spares profile for other components.

Mr. VOLKMER. By the way, it is the lack of the spares that got you in the problem with the heat exchanger, as I understand it. That heat exchanger, made back in 1977, was really always planned to be used for an engine for certifying purposes and never for flying purposes. Is that correct?

General ABRAHAMSON. It was used in an initial R&D engine, and then put into a second engine. In fact, it had two accidents and had to be refurbished and brought in again. Yes, sir, that is a factor. It is not a cause. It is a factor.

Mr. VOLKMER. Right, right.

General ABRAHAMSON. I would——

Mr. VOLKMER. Now how long——

General ABRAHAMSON. I am sorry, sir. Just for completeness——

Mr. VOLKMER. I would like to leave that up there because I want to ask another question with regard to it.

General ABRAHAMSON. At this point, We are running slightly under our cost plan in fiscal year 1983 in several areas. Very shortly, as part of our financial review process, I will be looking to see if there are additional money from where we are underrunning that we can divert into engine spares or into a head start on the structural spares program.

Therefore, depending on how this review comes out and our overall program priorities, there could be some initial expenditure on the structural spares in fiscal year 1983, but it would not exceed about $20 million.

Mr. VOLKMER. Now how long will the fiscal year 1984 spending for orbiter spares, for the structural spares, maintain an option for OV-105?

General ABRAHAMSON. It varies by contractor. Here (fig. 11) you see a reduced production operation at each of these major contractors. For example, the second one down, the wings are made at the Grumman Corp. in New York, the midfuselage at the General Dynamics Corp. in California, and you can see that for some of them the structural spares program moves them out in varying degrees but it is slightly longer than a single year. Therefore, perhaps a simple way of integrating this chart is to say that the structural spares program maintains an additional option for OV-105 for approximately 1 year, into fiscal year 1985.

However, there is an impact to the manning level and the program at each of these places. I will show you just one example so that you can begin to see what happens. This is the midfuselage activity at General Dynamics (fig. 12). This was their manpower dedicated to building the midfuselage of the shuttle, and you can see where their last midfuselage for orbiter 104 was indeed dropping.

We will be building up for the structural spares program. This is on the assumption that we can make some of this fiscal year 1983 money available to begin to do this in order to minimize that capability loss—but you can see that there has been an impact. However, we think that we can implement an efficient program that will give us the capability for an extended period.

Mr. VOLKMER. At General Dynamics, is any of that fuselage subcontracted by them to others?

General ABRAHAMSON. Oh, yes, sir, they——

Mr. VOLKMER. Are some of them already pretty well down?

General ABRAHAMSON. Yes, sir. That is what we call the third tier. Those contractors in many cases will have to restart some of their operations, which means that each of the end items we receive will be more expensive. Because, one, we have to restart some operations, and second because we are building them at a slower rate.

Mr. VOLKMER. The second question you may have to give us later in writing: If the Congress would add another $100 million for, specifically, OV-105—that is to the $100 million that is in there for the structural parts—what would be an efficient delivery schedule and total production cost for 105?

General ABRAHAMSON. I'll have to answer that for the record——

Mr. VOLKMER. We would appreciate that.

[The information follows:]

If Congress added $100 million to the fiscal year 1984 budget request of $100 million for structural spares, this would provide $200 million to initiate a fifth orbiter in fiscal year 1984. This would assume, however, that funds be available in fiscal year 1983 to initiate long-lead activities on OV-105. A previously planned delivery schedule would have delivered OV-105 in the mid-to-late 1988 timeframe. This would no longer be efficient and an early 1989 delivery would be more appropriate. The estimated run out cost would be approximately $1.9 billion (in real-year dollars).

General ABRAHAMSON. But I would make the point that, No. 1, obviously whatever is done has to be done in the context of the overall budget and requires approvals, and there are several cost profiles. You could try to build it quickly or you could spread it out over a long period of time. Those are strategies that are involved with production and that is why I prefer to answer that for the record.

Mr. VOLKMER. Could I have the other chart, right before this one?

General ABRAHAMSON. Yes, sir.

Mr. LUJAN. Could we straighten out something on that question?

Mr. VOLKMER. Yes. Go ahead.

Mr. LUJAN. Which would you prefer, an additional $100 million for a fifth orbiter or $100 million for spares?

General ABRAHAMSON. Sir, we are constrained by the President's budget and the context of the President's budget; however, we think that we have a good budget at this point in time.

Mr. VOLKMER. Looking at that, though, if we delay 105—don't do anything, but leave the budget as it and these structural parts, then, as they are—and then we say—and I know you may have to answer this, too, in writing, and I would like to have it—let's say, though, that this time next year the Congress and maybe the White House and everybody, because of changes, decides that we will go with 105 now starting in fiscal year 1985. By 1985 you have problems there with General Dynamics again. How much is it then going to cost us, and how long is it then going to take?

Therefore, we have two parts to the answer, and I would like to have it as soon as possible.

General ABRAHAMSON. Yes, sir.

[The information follows:]

If we proceed with the $100 million structural spares program in fiscal year 1984 and are given full authority to proceed in fiscal year 1985, a delivery of OV-105 could be achieved in 1989. Estimated total production cost would be approximately $2.0 billion (in real-year dollars).

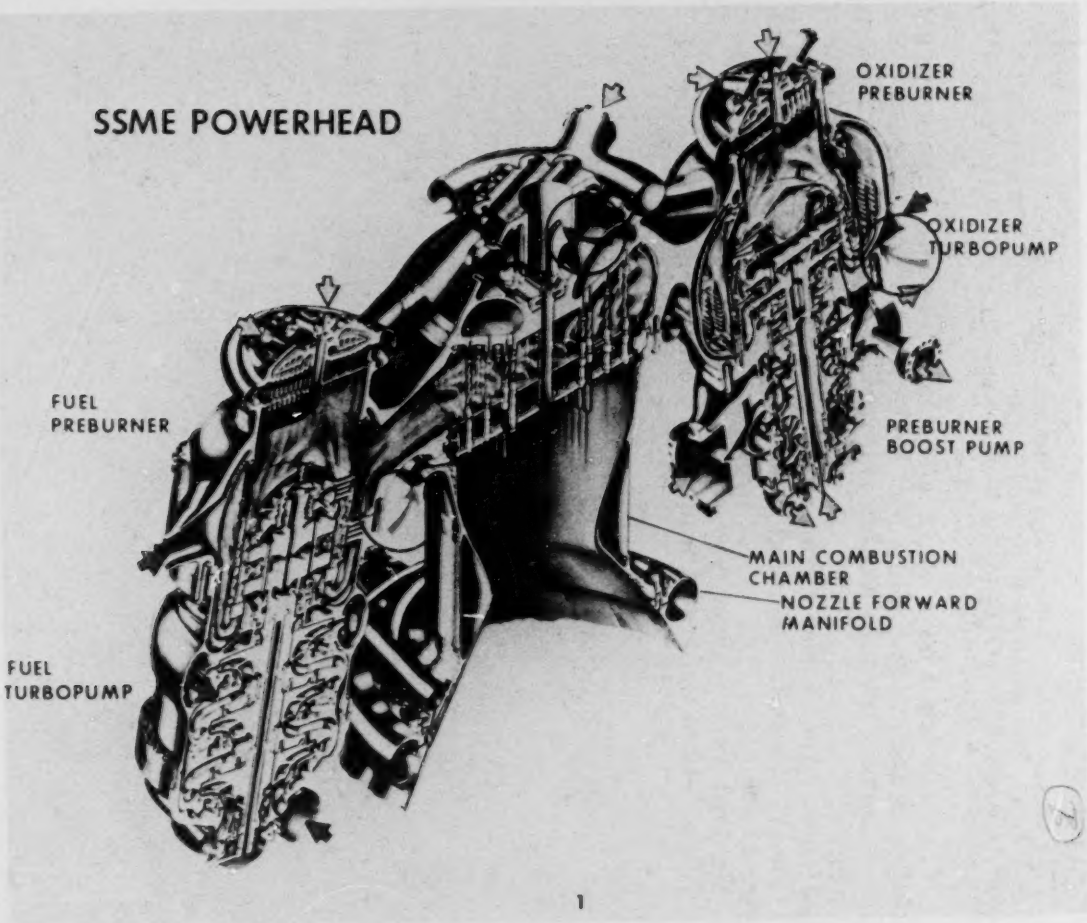
Mr. VOLKMER. I have other, additional questions but we are getting late and we still have Mr. Hodge on the task force. I would like to submit them in writing and request that we hold the record open——

General ABRAHAMSON. Fine, sir.

Mr. VOLKMER [continuing]. And not take too long to get the answers back.

General ABRAHAMSON. Yes, sir.

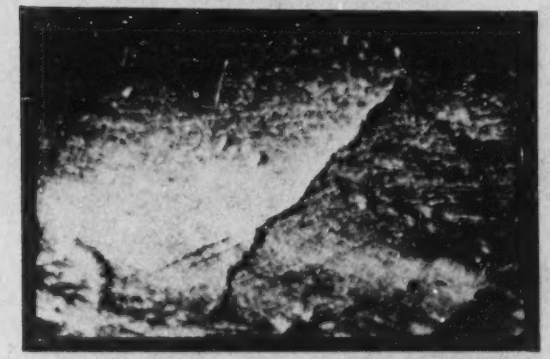
[Figs. 1-12 of General Abrahamson's oral presentation follow:]


SSME POWERHEAD
OXIDIZER PREBURNER
OXIDIZER TURBOPUMP
FUEL PREBURNER
PREBURNER BOOST PUMP
MAIN COMBUSTION CHAMBER
NOZZLE FORWARD MANIFOLD
FUEL TURBOPUMP

NASA

CHALLENGER ENGINE PROBLEMS

FIRST LEAK (ENGINE 2011)



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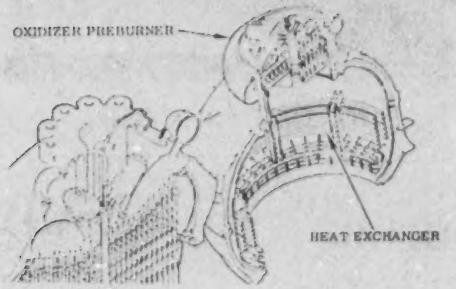
- LOCATED – FRF NO.2
- CAUSE: WELDING PROCEDURE DEFICIENCY

SECOND LEAK (ENGINE2016)

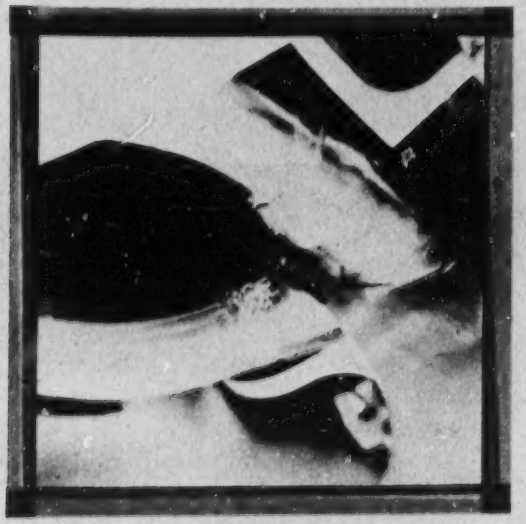


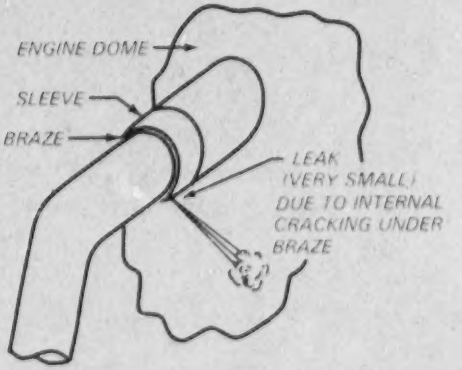
- INFINITESIMAL LEAK – DETECTED IN ROUTINE TEST AT KSC
- CAUSE: DEFICIENT WELDING

NASA

CHALLENGER ENGINE PROBLEMS
(CONTINUED)

THIRD LEAK (ENGINE 2015)





- **DETECTED** – DURING SPECIAL FOLLOW-UP TESTS ON PAD
- **CAUSE:** UNKNOWN, BUT DISCOVERED ON OTHER ENGINES TOO

NASA

ACTION TO PREVENT FUTURE PROBLEMS

- BALANCE ENGINES FOR SPARES THROUGH 1983
- LIMIT POWER LEVELS TO 104% (AND BELOW) FOR AN EXTRA "OPERATIONAL MARGIN" UNTIL OCT 85
- RELAX 109% CERTIFICATION SCHEDULE
- ADD MARGIN TO PRODUCTION:
  - INCREASE "BANK TIME"
  - ADD MANUFACTURING ATTRITION COMPONENTS
- IMPROVED LEAK TESTING IN ALL PHASES OF THE PROGRAM
- IMPROVED QUALITY ENGINEERING

1303

RESEARCH AND DEVELOPMENT
FISCAL YEAR 1984 ESTIMATES
BUDGET SUMMARY

OFFICE OF SPACE FLIGHT — SPACE TRANSPORTATION SYSTEMS PROGRAM

SUMMARY OF RESOURCES REQUIREMENTS
(MILLIONS OF DOLLARS)

	1982 ACTUAL	1983 CURRENT ESTIMATE	1984 BUDGET ESTIMATE
SPACE TRANSPORTATION CAPABILITY DEVELOPMENT	2,623.3	2,144.1	1,927.4
SHUTTLE DDT & E	894.0	------	------
SHUTTLE PRODUCTION AND CAPABILITY DEVELOPMENT	1,282.7	1,729.3	1,500.0
UPPER STAGES	106.7	167.0	143.2
SPACELAB	100.8	121.2	119.6
ENGINEERING AND TECHNICAL BASE	183.1	70.3	93.1
PAYLOAD OPERATIONS AND SUPPORT EQUIPMENT	46.3	44.4	53.2
ADVANCED PROGRAMS	9.7	11.9	15.0
TETHERED SATELLITE SYSTEM	------	-------	3.3
SPACE TRANSPORTATION OPERATIONS	466.5	1,453.7	1,570.6
SHUTTLE OPERATIONS	435.3	1,370.7	1,520.6
FLIGHT OPERATIONS	(71.3)	(330.1)	(315.0)
FLIGHT HARDWARE	(357.6)	(692.1)	(848.4)
LAUNCH AND LANDING OPERATIONS	(6.4)	(348.5)	(357.2)
EXPENDABLE LAUNCH VEHICLES	31.2	83.0	50.0
DELTA	(30.4)	(83.0)	(50.0)
SCOUT	(.8)	(------)	(------)
TOTAL SPACE TRANSPORTATION SYSTEMS	3,089.8	3,597.8	3,498.0

OFFICE OF SPACE FLIGHT

SHUTTLE/ELV REIMBURSABLE USERS

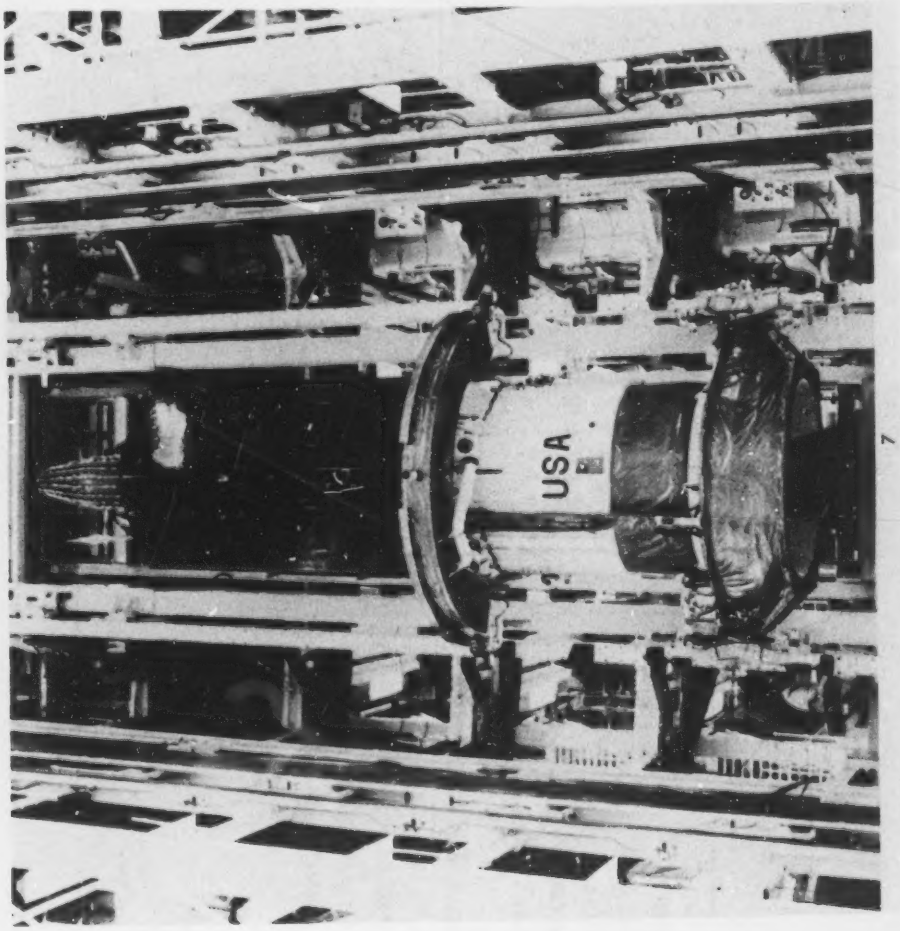
(EXCEPT U.S. GOVERNMENT AND DOD)

DOMESTIC PAYLOADS BOOKED				
USER	TOTAL	ELV ONLY	SHUTTLE ONLY	DOUBLE BOOKED
AT&T LONG LINES	3	1	2	
GTE SATELLITE CORP #	2		2	
HUGHES COMM, INC	3	3		
HUGHES COMM SERVICES, INC	5		5	
SOUTHERN PACIFIC COMM	3			**3
SATELLITE BUSINESS SYSTEMS	2		2	
SPACECOM	3			
SATELLITE TELEVISION CORP	6		6	*
AMERICAN SATELLITE CO	3			3
RCA AMERICAN COMM, INC	14	3	10	1
WESTERN UNION TELEGRAPH CO,INC	2		1	1
U.S. SATELLITE SYSTEMS	3	1	2	
TOTALS	**49**	**8**	**33**	**8**

FOREIGN PAYLOADS BOOKED				
USER	TOTAL	ELV ONLY	SHUTTLE ONLY	DOUBLE BOOKED
WEST GERMANY (BMFT)	2		2	
MBB (WG)	1		1	
TELESAT CANADA	8		8	*
INDIA	2		2	
INDONESIA	3		3	
ARAB SATELLITE COMM ORG # #	1		1	
AUSTRALIA	2		2	
COLOMBIA	2			
ITALY	1		1	
JAPAN (SHARED SPACELAB)	1		1	
UNITED KINGDOM	2			2
NATO	1	1		
RADIO-TELE-LUXEMBOURG	3		3	**
INTELSAT	18	6	12	***
CNES (SHARED SPACELAB)	1		1	
BRAZIL				**
BRITISH AEROSPACE	1		1	
UNITED SATELLITES	3		3	
MEXICO	2		2	
ESA (launch & retrieve)	1		1	
ORION	4		4	
* NO. OF FLIGHTS ARIANE BOOKED				
TOTALS	**57**	**7**	**48**	**2**

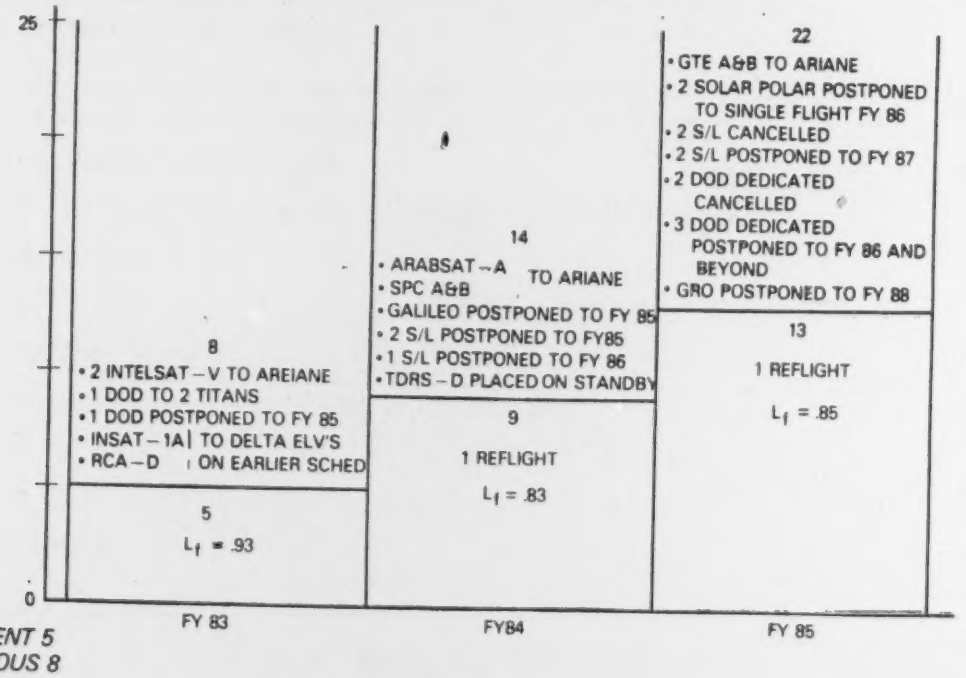
2 GTE BOOKED ARIANE ONLY

1 ARABSAT BOOKED ARIANE ONLY


USA

NASA

MANIFEST


25
0
8
• 2 INTELSAT – V TO AREIANE
• 1 DOD TO 2 TITANS
• 1 DOD POSTPONED TO FY 85
• INSAT – 1A TO DELTA ELV'S
• RCA – D ON EARLIER SCHED
5
L_f = .93
14
• ARABSAT – A TO ARIANE
• SPC A&B
• GALILEO POSTPONED TO FY 85
• 2 S/L POSTPONED TO FY85
• 1 S/L POSTPONED TO FY 86
• TDRS – D PLACED ON STANDBY
9
1 REFLIGHT
L_f = .83
22
• GTE A&B TO ARIANE
• 2 SOLAR POLAR POSTPONED TO SINGLE FLIGHT FY 86
• 2 S/L CANCELLED
• 2 S/L POSTPONED TO FY 87
• 2 DOD DEDICATED CANCELLED
• 3 DOD DEDICATED POSTPONED TO FY 86 AND BEYOND
• GRO POSTPONED TO FY 88
13
1 REFLIGHT
L_f = .85
FY 83
FY84
FY 85

CURRENT 5
PREVIOUS 8

8

MC 83 074

1307

NEW SHUTTLE CUSTOMERS

DOMESTIC

- GTE SATELLITE CORP (GSTAR C)
- ORION SATELLITE CORP
- UNITED STATES SATELLITE SYSTEMS INC

FOREIGN

- MEXICO
- AUSTRALIA
- COLOMBIA (ON HOLD DUE TO CHANGE OF ADMINISTRATION)

DISCUSSIONS ONGOING WITH:

- ADVANCED BUSINESS COMMUNICATIONS, INC
- CANADIAN MINISTRY OF COMMUNICATIONS
- CBS, INC
- DOMINION SATELLITE NETWORK
- FAIRCHILD SPACE & ELECTRONICS CO
- FORD AEROSPACE SATELLITE SERVICES CORP
- INMARSAT
- ITALY
- PAKISTAN
- KOREA
- SWITZERLAND
- RAINBOW SATELLITE, INC
- U.S. SATELLITE BROADCASTERS, INC
- SWEDISH TELECOMMUNICATIONS ADMIN

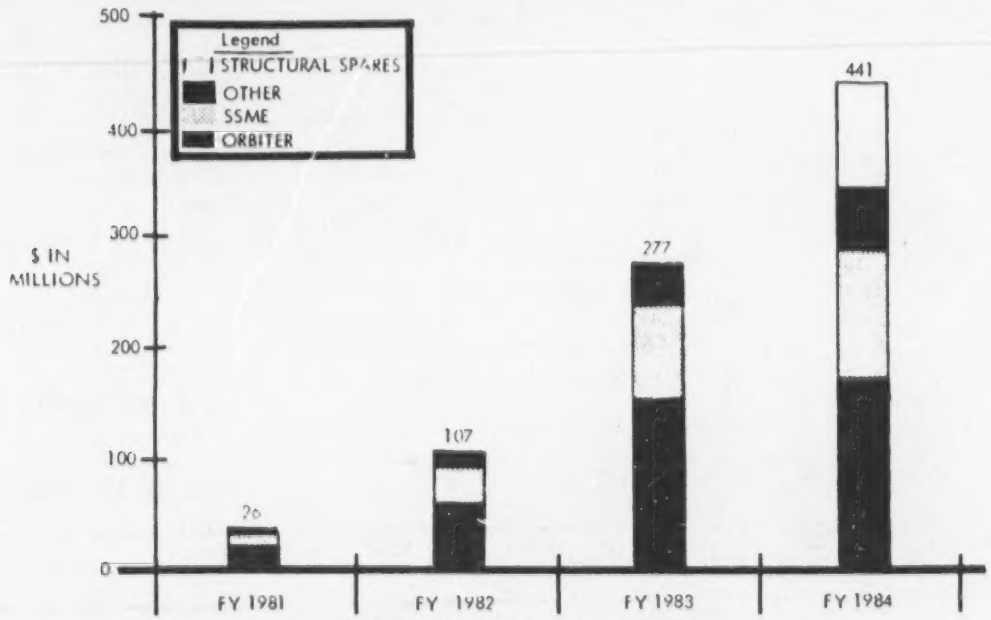
MC – 83 – 063
2/25/83

1308

19-605 O—83—83

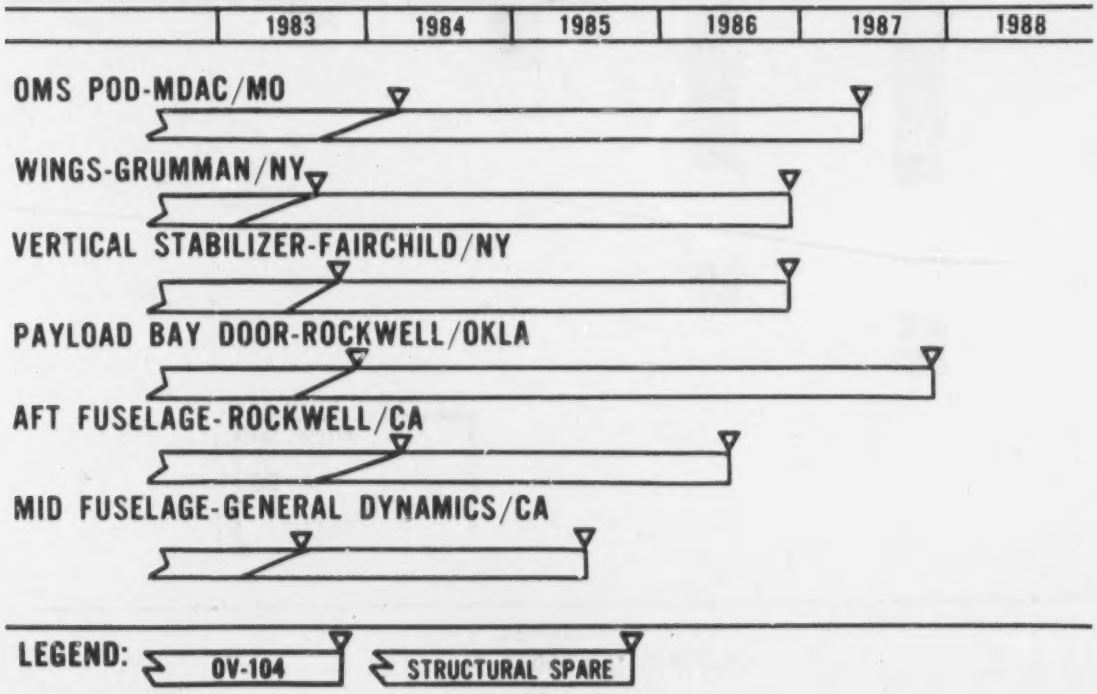
NASA

SHUTTLE SPARES FUNDING
to support Operations
(DOLLARS IN MILLIONS)



1309

NASA STRUCTURAL SPARES PROGRAM
TYPICAL POTENTIAL EXAMPLES



Mr. VOLKMER. Thank you very much, General Abrahamson, and I look forward to 6 going off before the end of the month.

General ABRAHAMSON. So are we, sir.

Mr. VOLKMER. You'll do it.

John Hodge, Director of the Space Station Task Force, I am pleased to have you here with us, Mr. Hodge. Your statement has been received and reviewed, and will be made a part of the record. If you wish you may summarize and then we will go right to questions and answers, or you can read the whole statement, however you so desire.

[A biographical sketch of Mr. Hodge follows:]

JOHN D. HODGE

John D. Hodge was appointed Director of NASA's Space Station Task Force on May 20, 1982. The Space Station Task Force is responsible for the development of the programmatic aspects of the space station as they evolve toward a potential new initiative.

Mr. Hodge has previously served NASA from 1959–1970, both at Langley Research Center, Hampton, Virginia, with the Space Task Group as Assistant Chief for Flight Control, and then at Johnson Space Center, Houston, Texas, as Chief, Flight Control Division and as Manager, Advanced Missions Programs prior to his departure in 1970.

Since 1970, Mr. Hodge has been associated primarily with the Department of Transportation, with his most recent capacity as Associate Administrator for Policy, Plans and Program Management, Research and Special Programs Administration, from 1977 to his rejoining NASA.

Mr. Hodge received his BS (Engineering) with 1st Class Honors, in 1949 from University of London, London, England. In 1966 the City University, London England, bestowed a honorary degree of Doctor of Science on Mr. Hodge.

The Department of Transportation Secretary's Award for Meritorious Achievement—Silver Medal was awarded to Mr. Hodge in 1980. Numerous awards and recognitions have been awarded to Mr. Hodge including NASA's Medal for Exceptional Service in 1967 and 1969.

Born in Essex, England, February 10, 1929, Mr. Hodge and his wife, the former Audrey Cox, have four children. They reside in Great Falls, Virginia.

STATEMENT OF JOHN D. HODGE, DIRECTOR, SPACE STATION TASK FORCE, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, ACCOMPANIED BY PHILIP E. CULBERTSON, DEPUTY ASSOCIATE ADMINISTRATOR; AND LT. GEN. JAMES A. ABRAHAMSON, ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT

Mr. HODGE. Thank you, Mr. Chairman. I would like to make just a few statements. Mr. Culbertson, who is the Associate Deputy Administrator, is with me today.

I would just like to make a few points before we go directly into questions. The first point is that what we have going right now is not a Space Station program but a planning effort. Our purpose is to find out what is needed to make a rational decision with regard to the space station. That knowledge will enable both Congress and the President to make a specific decision on whether or not to go ahead with the program.

The second point is that our plan is consistent with the new national space policy published in July 1982, in that that calls for a permanent presence in space. What we are looking for is: "What do we mean by a permanent presence?"

We are doing some things a little differently this time than we have before. Our approach to the space station definition is, first of all, to do an extensive definition. We really believe that we should

go a little further into the definition of a program than we have in the past before we start to commit the hardware, because we believe that overall we can reduce the cost of the program that way. It is the modifications to a program after the go-ahead has been given that very often increase the cost of a program. We are going to, to a large extent, use in-house resources to do the preliminary engineering, the trade studies, during this definition period. At the moment, we are deliberately avoiding any focus on configuration. It is really relatively easy to pick the configuration once you know what it is you want to do with it, but it is very difficult to find customers once you have picked a configuration that will not do certain things.

Our initial emphasis during this first 8 months and for a large part of this year is on mission requirements and the functional capabilities of the various pieces of the architecture that we are talking about. Another thing is that we have made a very deliberate effort to bring the user community, the customers—and we are thinking of these people as customers—right from the very beginning to participate in the definition of their requirements and what capabilities they want, so that in fact when we build it, it will be user-friendly.

We have considered from the very beginning the potential for international participation. A number of foreign countries are presently doing requirement studies similar to what we are doing now. We have made no commitments with regard to how they might participate in a future program, but at least we are looking to them as a potential customer and a potential user. We are working closely with the DOD, particularly with the Air Force. They are also doing parallel studies and, in fact, are participating in the contractor studies which we have had this year.

We are looking very carefully at what kind of technology we think we are going to need in order to make this program useful and lower in cost. For the time being, we are thinking that the space station will be fundamentally shuttle-tended. It will be compatible with the shuttle and supplied by the shuttle, although the possibility of unmanned logistics vehicles is still in the back of our minds. We do not know for sure whether that is going to be a better way to do it, but by and large we are thinking only of using the shuttle at the moment.

I keep using the word "user-friendly," and I will continue to do that. Many of our customers say they have heard that before, but we are working very hard to improve the relationship between the customer and ourselves. We are looking at a program which is evolutionary in nature, something which gives us an affordable initial operating capability which can grow. However, nevertheless, the first piece will be useful.

For the purposes of planning, we are targeting toward an initial operating capability in the 1991 time frame. For the purposes of framing the problem, we are using an initial program cost for DDT & E of $5 billion, although the unknowns are such that we are using numbers like $4 to $6 billion. I think it is that indeterminate at the moment. For the 1984 budget request we have asked for a total of $14 million. I would like to make the point that the program is being conducted by the whole of NASA, and there are

pieces that are supporting directly the space station in the budgets of General Abrahamson, Dr. Kerrebrock, and Dr. Edelson, and they are specifically for the space station. In addition to that, there is some work going on of a more generic nature which is applicable to the space station, which General Abrahamson talked about earlier.

I would finish up by saying it is 10 years since skylab flew, and I would like to say that there was a major difference between skylab and the Salyut series. That is that skylab was never installed as a permanent facility. We had no resupply capability for it; therefore, it was intended that it would eventually reenter, whereas the Salyut series is a permanent structure in orbit and is resupplied by both men and capability.

Thank you. I would be very happy to answer any questions.

[The prepared statement, plus answers to questions asked of Mr. Hodge follow:]

Statement of

John D. Hodge
Director
Space Station Task Force

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives

Mr. Chairman and Distinguished Members of the Subcommittee:

I appreciate the opportunity to appear before you today and review the space station planning activity now underway at NASA. It is my hope that this review will provide the Subcommittee with an understanding of what this activity is and why it is essential.

At the outset, before discussing specific activities, let me emphasize three key points:

- o NASA has underway a modest planning effort to define a possible space station. No approval for a development program is currently being sought.

- o Adequate space station definition is essential if Congress and the Administration are to be able to make an informed decision on whether the United States should proceed with a station as the next major initiative in space.

- o Our planning is consistent with and supports the President's National Space Policy in which a key objective is "to continue to explore the requirements, operational concepts, and technology associated with permanent space facilities."

The President's policy reaffirms the commitment to leadership in space that Congress mandated in the Space Act of 1958. Our space station planning effort, which is not dissimilar to the strategic planning undertaken by any large organization in the normal course of doing business, focuses upon a space station in part because such a system offers one potential approach to secure this position of leadership not in the decade of the 1980's but, later, during the 1990's when the U.S. space systems now in operation will have matured. The Space Shuttle is on its way

to becoming a fully operational space transportation system. Lead times for major space systems are long and the cycle for a space station could approach ten years. Moreover, the Soviet Union appears, for their own reasons, committed to a permanent presence in space, utilizing, for now at least, the Salyut space stations.

Given what is at stake, it seems to us prudent to examine what is involved in any future U.S. space station. We must understand its capabilities, costs, and key, basic technologies, as well as potential user requirements and schedules. It is NASA's view that a space station will be the next logical step in space and our current activities are directed toward developing sufficient information for Congress and the Administration to make an informed decision on the appropriate course of action.

APPROACH TO SPACE STATION DEFINITION

Mr. Chairman, I believe it would help you and the members of the Subcommittee to better understand the planning activity NASA is conducting if I were to outline, very briefly, the overall approach the Agency is taking to space station definition. Our strategy is simple. It is to conduct in-house an unusually extensive definition of a potential space station. By unusually extensive, I mean approximately three years of review and analysis prior to any potential development activity so that we would have a thorough grasp of the space station before we were to proceed to design and development. We would understand the technologies involved. We would know specifically what missions were to be performed, in what timeframe and what attributes a station would have to have to carry them out. We would have a firm and credible understanding on cost estimates and schedules.

This strategy avoids a premature emphasis upon configuration and design. It forces us to think through clearly and at the beginning what any future space station would be expected to do. It also is the only way I know to protect against the potential of costly slips in schedule and performance.

I should add that this approach, of NASA devoting greater resources to definition prior to development, is the most important lesson learned from Don Hearth's study of project management in NASA, a study undertaken at the request of the Committee.

Another key element of this space station definition strategy is early involvement by the potential users of a space station. Any future space station, to be successful, must be "user friendly." By that I mean, it must be relatively simple for those communities who utilize space to take advantage of the capabilities provided by a station. This concept of "user friendly" can only be realized if the space station users are part of the planning process. Thus,

we are reaching out to the user communities, to hear their thoughts about a space station and have their particular requirements identified and factored into our planning.

Potential users of the space station would likely be the science and applications communities. By providing a permanent presence in space, by offering the potential advantages to scientists of both manned and unmanned spacecraft, a station could significantly enhance our understanding of natural phenomena and our ability to utilize space systems for direct benefits here on earth.

Another user of a space station might be the Department of Defense, which like the science community and the commercial communications industry, uses the unique vantage point of space to carry out some of its responsibilities. We have sought and received the participation of the Department in our planning. A representative from the Air Force's new Space Command serves on the NASA Space Station Task Force, and the Air Force has contributed a small amount of money to the space station mission analysis studies enabling the eight contractors to focus upon requirements unique to national security.

Our approach to space station definition includes an international dimension. As this Subcommittee knows, several nations besides the United States and the U.S.S.R. possess mature space systems and have developed advanced capabilities. This sophistication makes international cooperation in a future U.S. space station program a real possibility, especially given our long and successful experience with cooperative projects in space. My own belief is that such a cooperative venture in a space station would be highly desirable, under appropriate conditions. For now, NASA is trying to take no action that would preclude such a possiblity. In coordination with the Department of State, we have told representatives of the countries which appear interested in our space station planning - Japan, Canada, Italy, France and Germany - and of the European Space Agency of our activity, pointing out to them that we are engaged in but a definition effort and that no commitment to a space station exists. We have exchanged non-technical information with them about our mission analysis studies and expect to share our thoughts about space station architecture with them in the future. We also expect to hear from them about their mission requirements and resulting space station concepts. No discussions have taken place about potential development of space station hardware nor about specific arrangements for a cooperative venture.

Our approach to planning such a program also includes a focus upon technology. Assessing the readiness of aerospace technologies to support a space station endeavor, establishing the appropriate

levels of technology for a station, and devising a plan to move the necessary technologies from current status to desired levels are all tasks that must be done if there is to be a space station. To carry out these tasks, a Space Station Technology Steering Committee was established. Under the direction of Dr. Walter Olstad, this committee is conducting a broad examination of technology issues. In addition, the Steering Committee is considering the potential for a future space station as a research facility for the testing and development of new technologies.

Our approach to space station definition is based upon a conviction that a station would be evolutionary in character. That is, it would be relatively small though functional in its initial phase (which, for planning purposes, we assume to be 1991) but capable of increased capabilities over time though the addition of further elements or the acceptance of newer technologies, or both. This evolutionary character is attractive in several ways. It provides a new dimension to the range of possibilities now under consideration. It will also enable us to plan realistically. By starting small, by conceiving a station that is modest in initial capability, we can lay out a possible program that appears modest in initial cost. Our planning now assumes a tentative cost range of $4-6 billion (in constant dollars) through initial operating capability in the 1991 timeframe. I say "tentative cost range" because one purpose of our current planning activity is to sharpen our estimates of cost and gain the necessary confidence in them for presentation to you and the Administration. $4-6 billion is of course not an inconsequential sum. But in relative terms, in comparison to other high technology enterprises, it is not excessive. If in fact a station could be built for this estimated amount, it would be roughly one-third the development cost of the Space Shuttle and about one-tenth the cost of the Apollo expeditions to the Moon.

CURRENT ACTIVITY

Focusing and directing the Agency's space station planning activity is the Space Station Task Force, a small group established last May by the NASA Administrator to conduct the definition effort. The Task Force is composed of some 25 individuals from both NASA Headquarters and the Field Centers. In an arrangement stemming from its agency-wide character, the Task Force is not organizationally part of NASA's line program offices. As its Director, I report to Mr. Philip E. Culbertson, NASA's Associate Deputy Administrator.

To carry out its responsibilities, the Task Force established three working groups. The first one, the Mission Requirements Working Group, is managing the space station mission analysis studies which were initiated last August and will, this Spring, integrate the results of these studies into sets of time-phased mission requirements. The second working group, the Systems Working Group, is responsible for the analysis of systems requirements and

characteristics and will identify the trade studies we expect to conduct in FY 1984. This working group is also responsible for thinking through system operations - the preliminary analysis of how a potential space station would function once launched and checked out. Operational requirements -- system and subsystem requirements brought about by the unique operational nature of the station -- must be considered carefully and, I believe, considered from the very beginning. The third working group is focusing upon how NASA in the future would procure and manage a space station program were a space station initiative approved.

As a major part of our space station planning effort, the Task Force is establishing a new group to conduct what we call "systems engineering." This is an activity of a technical nature that balances and brings together the various systems and subsystems into one integrated whole. It is a traditional task performed by engineers as they plan complicated systems. The Systems Engineering group will orchestrate the necessary trade studies and both identify and evaluate important technical options.

FY 1984 BUDGET REQUEST

In the budget request for Fiscal Year 1984, NASA is allocating $14 million for specific space station planning activities. These funds would be earmarked to: (1) devise an overall "architecture" or conceptual framework for a possible space station based upon an examination of potential space station missions. This examination, which will provide us with an essential understanding of functional capabilities, will be completed in April or May of this year; (2) conduct "trade studies" which are a series of technical analyses that would identify and review potential system and subsystem options (such studies are a typical type of activity when engineers plan a complex space system); (3) begin a "systems engineering" activity which comprises studies of a technical nature that reconcile, balance, and integrate the competing engineering requirements at the system and subsystem level and define potential cost and capabilities envelopes. For these three planning activities, we would earmark $6 million (of the $14 million) that is set aside for space station planning in the Office of Space Flight's Advanced Programs request.

An additional $6 million would augment on-going efforts in the Agency's Space Research and Technology program principally in engineering activities to better understand key, evolving technologies in areas such as system control and data management, regenerative life support, and electric power generation, storage and distribution. Our intention is to establish generic test capabilities at selected NASA centers. New technologies and approaches would be tested and evaluated. Our objective is to provide a repertoire of technical options for a potential space station. The remaining $2 million is requested in the Space Science and Applications program primarily

for studies of potential science and applications payloads that would use a future space station. An additional $29 million has been identified in the FY 1984 budget request of the Office of Aeronautics and Space Technology to provide generic support to the technological areas under investigation.

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Mr. Chairman, in this brief statement I have attempted to highlight the major characteristics of our space station planning activity as well as to describe the specific activities for which NASA is requesting Fiscal Year 1984 funds. In the interest of time, I have not gone into great detail about these activities nor have I mentioned a number of space station-related activities taking place outside of NASA. These activities include the initiatives underway by the space science communities to examine the potential of a space station, the space station study by the Office of Technology Assessment, the mission requirements studies that are now near completion, the review being conducted by a working group of the Senior Interagency Group (Space) in the Executive Branch, and, of course, the extensive experience with space stations achieved by the Soviet Union with its Salyut series spacecraft, most notably the Salyut 6 and Salyut 7 space stations.

I would be happy to discuss these and any other aspects of space station that are of interest to you. Before concluding my prepared statement, though, let me note that it was ten years ago this Spring when the United States placed in orbit and operated a space station of its own. Since that time, many developments have occurred in the world of space. The most notable, perhaps, is the operational success of the Space Shuttle, a truly remarkable craft. Now that we have, a full decade after the three Skylab missions, the capability for routine access to earth orbit, it is appropriate to proceed with a definition effort that enables us to understand fully what a permanent space station involves and how it could enhance the presence in space of the United States.

At this point, I will try to answer any questions that you may have.

Questions submitted by Chairman Volkmer during the March 1, 1983, hearing.

QUESTION MFA-1:

a. Could you elaborate on your plans within the Advanced Programs activities?

b. How much funding is planned for Space Station activities?

c. What other study activities will be supported?

ANSWER MFA-1:

a. Advanced Programs will continue to pursue studies and development of options to fully utilize the potential of the STS, and for its orderly evolution. The $15 million budget will be allocated $6 million to Space Station, and $9 million to all other activities. These are described in (c) below.

b. Of the total $15 million requested for Advanced Programs in FY 1984, $6 million is to fund Space Station activities. There is also $6 million contained in the Office of Aeronautics and Space Technology budget request to augment Space Station research and technology development and $2 million in the budget of the Office of Space Science and Applications for a total FY 1984 request of $14 million.

c. We will continue to concentrate on four areas as follows: 1) Orbital Services: In this area, we will continue to define requirements and concepts of a Teleoperator Maneuvering System, and tools and techniques necessary for satellite servicing near and remote from the orbiter. 2) Advanced Transportation: In this area, we will continue early studies in Shuttle-Derived Launch Vehicles, and Shuttle growth items such as an Aft Cargo Carrier. We will also continue definition of an evolutionary Orbit Transfer Vehicle concept. 3) Platforms: In this area, we will begin definition of a number of promising applications of space tethers, and continue low level unmanned platform concept definition for both low and geostationary orbit. 4) Manned Systems: In this area, we will continue advanced development of improved suits, and studies to define human roles in space.

QUESTION MFA-2:

NASA has previously completed "Phase B" definition phase studies on a "Space Platform" and a "Power Extension Package?"

a. How do these programs fit into NASA's long range plans for a Space Station?

b. What is the relative priority of these two programs?

ANSWER MFA-2:

a. The Power Extension Package is not part of our present long-range plan for the Space Station, although the technology and definition activities which have been completed are relevant to our Space Station planning. We currently view the relationship between a Space Station and a Space Platform in essentially the same way as we view the relationship between a Space Station and the Space Telescope; i.e., the Space Station should be designed in a way which will enable it to effectively provide for man-tending of free-flying spacecraft where man-tending can enhance the effectiveness of those spacecraft.

b. Since neither of these two projects is an integral part of our present Space Station definition we have not determined their priority order.

QUESTION MFA-3:

One of the primary objectives of "Power Extension Package" is to extend the on-orbit stay time for the Shuttle orbiter.

Does NASA presently view the Power Extension Package as a future program requirement?

ANSWER MFA-3:

As of this time, we have not identified an urgent need to extend the Shuttle on-orbit stay time beyond that which can be accommodated within the present Shuttle design capability, as augmented by the fifth cryogenic fuel cell kit. If such a requirement were to surface, we would be in a position to consider PEP as a candidate for inclusion in future budgets.

However, the PEP could only be used to extend the on-orbit time of the Shuttle to about 3 weeks. Beyond that time period, habitability and logistics become severe problems.

QUESTION MFA-4:

a. Please provide a breakdown of resources planned for Space Station activities in FY 1984 including Advanced Programs, Advanced Technical Development, and Space Technology funding as well as manpower?

b. What portion of these funds are planned for "in-house" and what portion for "contractor" activities?

ANSWER MFA-4:

a. The total request for Space Station augmentation is $14 million in FY 1984. $6 million is contained in the Office of Space Flight budget, $6 million in the Office of Aeronautics and Space Technology budget, and $2 million in the Office of Space Science and Applications budget, as shown:

SPACE STATION DEFINITION

FY 1984 BUDGET AND PLANNED ACTIVITIES

	FY 1984
OSF AUGMENTATION	6.0
Supporting Studies, e.g.	5.0
- Systems Analysis - Operations Techniques - Etc.	
General Support	1.0
- JPL - Commercial User Development	
OAST AUGMENTATION	6.0
- Space Energy Conversion - Platform Systems - Etc.	
OSSA AUGMENTATION	2.0
- Utilization of Scientific Payloads	

There are about 250 people NASA-wide working on Space Station planning activities.

In addition to the above funding, there is approximately $29 million of generic technology effort identified in the OAST Space R&T budget which would have applicability to a potential Space Station. It should be noted, however, that the same technology has utility in other applications.

b. Essentially all of the OSF ($6 million) and the OSSA ($2 million) funds are planned for contractor activities. Approximately 60 percent of the total OAST funding ($29 + $6 million) is planned for contractor activities.

QUESTION MFA-5:

Can a Space Station be justified without a complementary reuseable, on-orbit serviceable orbital transfer vehicle?

a. What are NASA's plans in fiscal year 1983 and 1984 regarding orbital transfer vehicle studies?

b. Is NASA still considering additional funding for orbital transfer vehicle studies in fiscal year 1983 as noted in a January 3, 1983, letter from the NASA Administrator to the Committee on Science and Technology?

NASA

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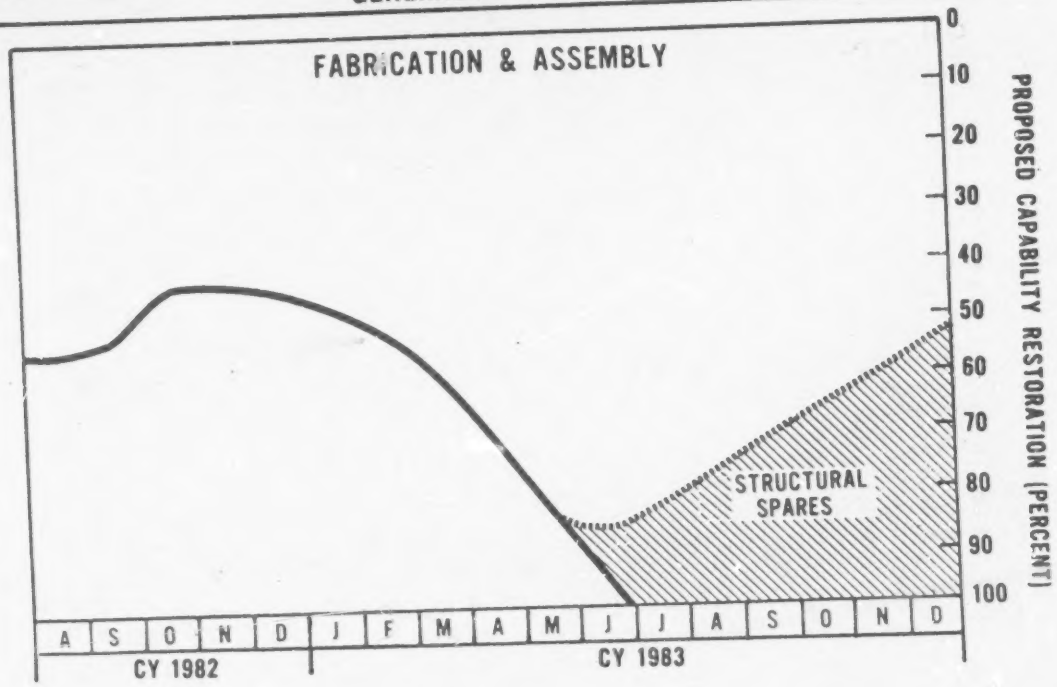

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ANSWER MFA-5:

A principal function currently being examined for a potential Space Station is utilization as a transportation node to higher energy orbits. While the principal elements of an initial Space Station capability are still under study, current requirements analysis indicate that orbital transfer vehicle (OTV) would be a useful adjunct to space capabilities.

a. In FY 1983 and FY 1984, NASA plans to initiate new competitive "Phase A" studies of the OTV, with specific consideration on the implications of eventual space basing. Additional, studies on aerobraking technology requirements are also being planned.

b. NASA is augmenting funds for research and technology applicable to an advanced OTV propulsion system.

QUESTION MFA-6:

Could you elaborate on the agency plans for "orbital service" studies in fiscal year 1984?

ANSWER MFA-6:

Orbital services activities will see the continuation of definitions, advanced development, and beginning of flight demonstration planning for a number of tools, equipment, subsystems, and techniques to enable astronauts to service and refuel satellites in orbit. We will continue concept definition of a Teleoperator Maneuvering System to allow the extension of these services to satellites not accessible by the orbiter, by bringing them to the orbiter and then placing them into their original orbit when repaired. This capability could possibly be extended to geostationary orbit repair and refueling, and we will begin studies to define such systems.

QUESTION MFA-7:

If one were to make the decision to extend the duration on-orbit time of the Space Shuttle--

a. What would be the impact on your basic Space Station approach?

b. Would you have to dedicate a Space Shuttle orbiter for this purpose?

c. Could this effort complement the Space Station effort?

b. Would this approach further justify the need for additional orbiters?

ANSWER MFA-7:

a. Extension of the Space Shuttle on-orbit duration would not impact our Space Station planning.

b. It would not be necessary to dedicate a Space Shuttle orbiter to extended duration missions if the principal additions were a Power Extension Package in the form of a removable kit.

c. Extension of the Shuttle on-orbit duration could complement the Space Station effort by providing earlier experience in a modestly increased manned stay time.

d. The need for additional orbiters is dependent on many factors possibly including extended duration missions. This specific interrelationship has not been established however.

QUESTION MFA-8:

Do you expect the Senior Interagency Group to participate in a decision on whether or not to proceed with a Space Station?

a. What studies, if any, are underway to support the Senior Interagency Group consideration of a Space Station?

b. When will these studies be completed?

ANSWER MFA-8:

Under the auspices of the Senior Interagency Group, the Space Station Working Group has been organized, chaired by John Hodge of NASA, with representation from the State Department, DOD, Commerce, Intelligence Community and the Arms Control and Disarmament Agency (ACDA). OSTP and OMB have been invited to have representatives on the Working Group.

a. The SIG will receive a report from the Space Station Working Group identifying the policy issues associated with a manned Space Station. The Space Station Working Group will not recommend any specific development program, but rather address the overall issues with respect to policy options. It is expected that the SIG will review the Working Group report and provide policy options for the President.

b. The Space Station Working Group of the SIG is scheduled to present their findings to the SIG in September, 1983.

QUESTION MFA-9:

Is NASA considering a combination of orbiter extended on-orbit stay time and an unmanned space platform as an alternative to a manned Space Station?

ANSWER MFA-9:

Our current planning envisions a Space Station architecture including both unmanned platforms and a manned base functioning in a synergistic manner.

QUESTION MFA-10:

Is NASA funding contract studies to look at alternatives to a manned Space Station?

ANSWER MFA-10:

A number of past studies have examined unmanned approaches to a Space Station, such as Shuttle-tended platforms. These studies represent part of the data base upon which current planning activities are proceeding. The current Space Station requirements studies include analysis of our capability to accommodate user mission requirements using Space Shuttle and unmanned spacecraft.

QUESTION MFA-11:

Do you expect robotics technology to play a significant role in the Space Station?

ANSWER MFA-11:

Yes. The basic question surrounding robotics is the allocation of duties and responsibilities: There are advantages to both man-operated and automated systems. A man gives you flexibility that may never be achieved with a machine and a machine gives you accuracy and precision far beyond the human capability. Thus, NASA's current planning includes the incorporation in a potential Space Station for the early 1990's of many automated functions so that many subsystems could be nearly autonomous (unmanned crew intervention). Robotics, an automation discipline, incorporates many automated functions to interpret and extend man's cognitive and physical instructions. True robotics, that which would incorporate artificial intelligence capabilities, is still in early development stages. However, robotics could ultimately play a significant role in future space operations and, therefore, the technology involved in robotics development is important.

In general, application of robotics technology on a Space Station could ultimately be employed to accomplish tasks external to the Station, such as docking assist, construction, vehicle fueling, satellite retrieval, and repair and upgrade functions. Robotics inside the station could potentially perform repetitious operations such as those envisioned for material processing or life sciences operations.

In FY 1983 NASA, through OAST, is funding efforts to develop robotics technology which can directly support Space Station as well as other space endeavors. This robotics research is in the areas of

vision systems, slave manipulators, supervisory control systems and the necessary end effectors, sensors, displays and controls.

QUESTION MFA-12:

What are the advantages and disadvantages of an automated robotics space platforms vs. a manned space platform?

ANSWER MFA-12:

Relative advantages attending unmanned and manned platforms are dependent on the mission requirements and the sensible course of action from performance and cost standpoints.

Unmanned platforms will tend to be favored for single purpose missions with well-defined tasks where possible failure paths can be anticipated (such as with the Space Telescope); for hazardous operations such as refueling or in environments which would preclude man's presence for extended periods as in the radiation belts; or when repetitious, fairly simple tasks only are required.

Manned platforms would be advantageous when the mission set is varied, if unanticipated situations or failures might occur, if real time decisions are required, such as response to observation, if supervision of various autonomous machines is necessary, or in general, when cognitive or manipulative functions beyond machine capabilities are required. The exact nature of these requirements and potential missions are not defined.

As machine capability increases more of the tasks currently performed by man will be done better and less expensively by automation. We would intend to automate any Space Station in an evolutionary fashion as fully as practical, leaving to man those functions which cannot be done by or cannot be entrusted to machines. Several activities are underway which will help us to better define the most cost effective man/machine roles for the 1990's.

Mr. VOLKMER. Thank you very much, Mr. Hodge.

Mr. Lujan.

Mr. LUJAN. Well, when you say "evolutionary," I kind of envision a Rube Goldberg contraption up there. Is that what you are thinking of basically?

Mr. HODGE. We are talking about evolution in two senses. It is possible that one could consider Rube Goldberg as a characterization for it, simply because in space we have the situation where we do not have to worry about things like aerodynamics. Things could be added in such a way that it would look rather unreasonable, I think, in our Earth-bound environment. In many respects, the space environment is more benign than the Earth-bound environment. We don't have to worry about earthquakes, windstorms, rain, or things of that nature.

A second kind of evolution has to do with technology. If we build the system essentially to last for as long as we can imagine—and let's pick a number like 10 to 15 years—during that time technology will advance significantly, if the past 10 years is any example. Therefore, we want to be able to build the system in such a way that we can replace technologies as they become available. Therefore, it is evolutionary both in a size sense, which means an increase in capability, and a technology sense, which will allow us to do things in a better way.

A typical example of the technology sense would be the potential improvement in computation and artificial intelligence, where more of the mundane kinds of tasks can be substituted from the man to the machine.

Mr. LUJAN. Have you looked at it primarily for the shuttle to go up, unload like a trucking company or something like that, and then move from there to do whatever other things we want?

Mr. HODGE. Yes. With due respect to the shuttle, I really think the shuttle in this concept is being used for what it was originally designed for, which was to tend facilities and to place things in orbit, rather than to act as a pseudo space station.

Mr. LUJAN. I am not sure if he is agreeing with you or not.

General ABRAHAMSON. Clearly the shuttle was designed to be a transportation system, but it is also an R&D vehicle. For short time periods, it can do, in my judgment, some very important and very new things as an R&D vehicle—I do not mean to improve the shuttle but engineering experiments, operations kinds of things that will eventually benefit and make space less expensive and more beneficial to everybody.

Therefore, I really think it is an improper characterization to say that it is only a truck, but it does do trucking very well.

Mr. LUJAN. We hear talk about using, perhaps, some of the external tanks for building in space, and from what I can gather, at least in my short experience in trying to look at these space issues, is that things that are built in space—whatever they may be, a space station—are of a flimsy nature because you do not need big, heavy beams in order for them to survive there. Clearly the external tank is not in the category of a flimsy kind of a tank. Would there be some disadvantages to using it, other than, you know, how many you are going to use?

Mr. HODGE. We are looking at that. There have been a couple of studies, one particularly by Professor Arnold on the west coast, to see what innovative things we could do with the external tank. The reason that it makes sense to think about that is that you can get the external tank into orbit at essentially no cost in performance. The thing that we have to look at is, if we can devise some innovative things to do with it, including using it for major modules for the space station itself, is what is the cost of modification in order to do that. Since the tank carries hydrogen and oxygen you would have to be able to modify it significantly. What we need to understand is the cost of that modification as against the cost of manufacturing a completely new module.

Mr. CULBERTSON. Let me add something to that because John was not around for the skylab program. The skylab, of course, started out as a tank. As a matter of fact, in the very early stages of skylab there was serious consideration of using the upper stage of a *Saturn 5* which had served as a propellant stage and was filled with propellant, and then we would outfit it on orbit as the workshop that it turned out to be.

We abandoned that when it appeared to us that the complexity of that on-orbit outfitting or refurbishing was almost an overpowering job. Then we went to using the structure of the tank as the outer shell of the skylab, but it was never filled with propellant. It was outfitted on the ground and flown.

Therefore, we are not novices at the idea of studying these sorts of things, but in fact the structure of a space station is probably the least expensive part of it. It is the systems which one must provide to make it a space station and the integration of all that into a single, complex organism which takes most of the cost. What we would save with using the tank is primarily a structure and the fact that we have already gotten that external tank into orbit, of course, which is a propellant advantage.

However, those are the kinds of considerations that have to be given to the overall economy of using it. Certainly, it is an attractive idea that, I think, the agency will continue to explore. That overall idea is, "What use can we make of those tanks?" If not for a space station, are there other effective uses of it on orbit, because as you pointed out earlier in General Abrahamson's conversation, it is a major element which we are not reusing. Once on orbit, it has a tremendous amount of energy stored into it, and we are looking at various ideas for its potential use.

Mr. LUJAN. Could you drill and thread and cut openings from the oxygen tank into the hydrogen tank in space?

Mr. HODGE. Yes, it is possible to do that. You would have to do some things on the ground and in the design to make it simpler to do. We would have to look at what kind of tools and what kind of capability in a man-machine sense that we would have to have to do that, but I do think that in general you would be finding a need for actual design modifications on the ground in order to simplify that process. What you really have to trade off there is the cost of doing it on the ground as against the cost of a man in orbit, which may be as much as $50,000 an hour.

Mr. LUJAN. Since we get so close to orbit, could we accidentally have an external tank in orbit, do you think?

Mr. HODGE. I do not think there is any possibility of that at all, at the moment, not accidentally. The profile of the launch is such that it always lands in the Indian Ocean.

Mr. LUJAN. Thank you, Mr. Chairman.

Mr. VOLKMER. Mr. Hodge, how long, what is the time frame for activities of the task force finally to make a report, and then there will be another group to make a determination on whether or not we have a permanency in space?

Mr. HODGE. We believe that it is appropriate to keep the nature of the task force going until such time as we have a fundamental decision on whether to proceed with the program. The advantage of that is that we can bring people in from all over the Agency to work on a detail basis. If the answer on whether to proceed or not comes out "no," we can send them back. We do not have to set up a structural organization, and that really is an advantage when you are doing this kind of an operation. We will probably stay in this configuration for at least a year. Mr. Culbertson might like to answer that.

Mr. CULBERTSON. I think it is certain that we will do the studies for a year because we will still be in fiscal year 1984 considerably longer than that year.

Mr. VOLKMER. What do you envision in the 1985 budget?

Mr. HODGE. Many of the studies which we are doing now are leading us to make a more informed decision about the 1985 budget. We are going to compile the results of the mission analysis work, and it is not just the work of the contractors but of the Space Science Board, and the Space Applications Board.

Mr. VOLKMER. You have in-house studies, do you not? There are some being done down at Johnson and some at Huntsville?

Mr. HODGE. Yes, and they are scheduled to conclude in the May time frame of this year. For the rest of this year, we are going to be taking a single set of time-phased requirements and converting them into a set of functional capabilities for the various pieces of the space station. The functional capabilities will enable us, first of all, to be clearer about how much money we are talking about over what time frame, the sort of duration, total cost, and maximum funding of the program. It will also allow us to structure the program so that we can go to the next level of detail.

What I would see happen, if it is possible for us, is that in the 1985 timeframe, to have space stations go to what has traditionally in NASA been called phase B or the detailed definition of the system.

Mr. VOLKMER. Well, NASA has already completed a phase B definition, have they not, on a space platform and power extension package?

Mr. HODGE. Yes.

Mr. VOLKMER. Now how do these programs fit into the long-range program on the space station?

Mr. HODGE. In many respects it is very fortunate that those studies have been done, because they are providing a set of data bases which allows us to trade off the various options. In fact, a great deal of the work that has been done at Marshall on the space platform is part and parcel of the data base which we are using to put the rest of this program together. The power extension package is

the basis for our understanding of the potential usage of large solar arrays for power systems of 12 to 50 kw.

Mr. VOLKMER. Is that also, the power extension package also part of that study as to permitting the orbiter to stay in space for a longer period?

Mr. HODGE. That was the purpose of that study, yes. There was some consideration as to whether there were advantages to be gained by extending the lifetime of the shuttle in orbit, in fact to do sortie kind of missions. The PEP that finally came out, gave an extension of about 22 days. The reason that there was that limitation is that the next thing that you have to replace after power is the lithium hydroxide system which means closing the loop, because you are going to fill the shuttle up with lithium hydroxide if you go much more than about 3 weeks.

Mr. CULBERTSON. In the studies that we are doing today, much of the analysis of the space station is to determine how it can increase the effectiveness or improve space operations for doing other sorts of things. The space station is basically a supporting facility.

In order for us to compare in rational ways the utility of a space station to do this, we must compare it to an environment which does not include a space station. That other environment is a shuttle extended-in-duration, with a PEP and those other things which would be necessary to fly with it. So, the power extension package which we have provides a piece of the basis for the examination of the effectiveness of a space station compared with other ways of doing space activities.

Mr. HODGE. There are in fact several things that are coming out of our mission now as to studies. It shows that under some circumstances there are missions which are enabled by a permanent presence with man, some things that it is very, very difficult to do unless you are there permanently. In many other cases, in fact probably half of the missions that we are looking at, you can increase the efficiency of the process depending on what the size of the mission model is. It is that tradeoff between efficiency and enabling missions that we have to understand before we can go ahead to say specifically what we should build at what time.

Mr. VOLKMER. Well, you basically know, within the definition of the phase B definition on the power extension package, the limits of the Orbiter, do we not?

Mr. HODGE. Yes.

General ABRAHAMSON. Yes.

Mr. VOLKMER. I mean, I am even a layman and it would appear to me that a space station would not have that much of a limit, even a manned space station.

General ABRAHAMSON. Yes.

Mr. HODGE. That is right. The difference that a space station fundamentally makes to the transportation system we have right now, is that it takes time out of the equation. You no longer have to worry about the amount of time you have to do things which is a significant advantage for certain kinds of missions.

Mr. VOLKMER. The time frame has already been proven to us by what the Russians have done——

Mr. HODGE. Yes.

Mr. VOLKMER [continuing]. As far as permitting people to be up there for longer periods.

Mr. HODGE. I think in the time frames we are talking about, the resupply of crews at 3- to 6-month intervals is no problem.

Mr. VOLKMER. Right, provide us with a breakdown of the resources planned for space station activities in fiscal year 1984, including such things as advanced programs with this money you are getting, advanced technical development, and space technology funding, as well as the manpower? I would like to know what portion of these funds are planned for in-house and what portion are for contractor activity, if any, on the latter. I will submit that question to you more in writing, if you would like to have it.

Mr. HODGE. Yes, sir.

Mr. VOLKMER. Now is the senior interagency group to participate in the decision on whether or not to proceed with a space station?

Mr. HODGE. The purpose of the study that we are doing for the senior interagency group is to review the policy with regard to the potential future of a space station. The schedule on that study is such that we are to present policy options to them for their decision in October of this year.

Mr. VOLKMER. Now will you have to describe those studies for them?

Mr. HODGE. What we intend to do is to put a series of options together, which is the natural way that policy papers are done, all the way from "do nothing" to "do everything," and then examine the issues that come out of that and present them in terms of policy options.

Mr. VOLKMER. What are the number of options, the type of options, that you are looking at right now?

Mr. HODGE. At one end of the spectrum, what we are looking at is essentially doing things exactly the way we do now, which is essentially the shuttle with its present capability, in a space station kind of sense tending unmanned satellites which are presently planned in the program.

The other end of the spectrum is a total transportation system, which includes the manned space station as a node, large platforms which are tended by the space station or by the shuttle, in both low-inclination orbits and high-inclination orbits, plus high-energy upper stages which will take you to the geosynchronous orbit. That really represents the far end of the spectrum. The question is, whereabouts in that spectrum should we work? It is really many options but we are trying to characterize it as two ends of that.

Mr. VOLKMER. Can you tell us at this time the advantages and disadvantages of an automated, say robotics, type of space platform versus a manned space platform?

Mr. HODGE. We have had some controversy over that subject. It is our intention—and this is the technology part of the program at the moment—to examine the potential for automation wherever it is appropriate. By and large, what we want to do is to put smart enough systems into the space station and the associated vehicles to reduce the cost of operation of the system and reduce the involvement of man to the largest extent possible.

One of the problems though is that people tend to confuse the difference between automation and artificial intelligence. The ques-

tion is: "How far can we go in that direction in the timeframe that we are talking about?" People are going to have various opinions on what that is, but the difference in technology between automation and then improving to what we have called "smart systems," which essentially are clever ways of putting in redundancy and things of that kind, and the infusion of artificial intelligence, is enormous. Now we are, as a nation, working on that subject. The question is, "How quickly will that occur?" There is a second part to that, and that is the question of the utility of man as an observer in situ, as against the utility of many as an observer on the ground. The question there is: "What data rates do you have to transmit in order to provide the man on the ground with the same set of information to make the same set of observations?" We do not know that, but we do know that it is far in excess of anything we currently have. The total band-width of the TDRSS is no where near enough to do that. It is nevertheless potentially possible in the future.

Therefore, I think what we are talking about is not whether or not we are going to use automation or whether or not we are going to move into the field of artificial intelligence, but the rate that we are going to do it. Then, you have the more philosophical problem of whether or not it is appropriate to have a man in space anyway. Those two things have to be played against each other, and we are looking at the program in that sense.

Mr. VOLKMER. Have you or your task force come to a conclusion, do you think, on the capability of doing it on the "smart" way?

Mr. HODGE. That is a good question. I suppose from a leap of faith point of view—and certainly Mr. Beggs has said it—we are coming from the point of view that at least in the initial phases here, for the first 10 years or so, that man will be involved in space and that in fact this other technology will not proceed fast enough for us to make that other decision, even if we wanted to.

I would like to think that we are being intellectually honest enough to examine that in its totality and make this decision in a rational way.

Mr. VOLKMER. We may have some additional questions for the record, and the minority informed me that they will have some. Other than that, that will conclude the hearing. I appreciate your being here, Mr. Hodge——

Mr. HODGE. Thank you for the opportunity.

Mr. VOLKMER. And General Abrahamson. We appreciate it very much.

Mr. VOLKMER. Our next hearing will be tomorrow, March 2, at 2 o'clock in this room. That will adjourn the committee hearing today. Thank you very much.

[Whereupon, at 4:05 p.m., the subcommittee recessed, to reconvene at 2 p.m., on Wednesday, March 2, 1983, in room 2325, Rayburn House Office Building.]

1984 NASA AUTHORIZATION

WEDNESDAY, MARCH 2, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2:10 p.m., in room 2325, Rayburn House Office Building, Hon. Harold L. Volkmer (chairman of the subcommittee) presiding.

Present: Messrs. Volkmer, Nelson, MacKay, Lowery, and Chandler.

Mr. VOLKMER. The subcommittee will come to order.

Today the subcommittee continues our hearings on the NASA fiscal year 1984 budget request. The organizations represented today play a significant and important role in the U.S. space program, and certainly influence program planning and direction. The Air Force serves as the Department of Defense agent in coordinating with NASA activities related to our national space transportation system. The European Space Agency has developed the space lab as a major part in the space shuttle program, and there are also several ongoing and future cooperative science and education programs.

The third organization represented today will be the Aerospace Safety Advisory Panel. This panel was established by Congress to provide a group of outside experts who would advise NASA on safety issues on both space and aeronautics flight and experimental programs.

Our first witness will be Edward C. Aldridge, Under Secretary of the Air Force, who will be followed by George Van Reeth, Director of Administration, European Space Agency, and by Willis M. Hawkins, chairman of the Aerospace Safety Advisory Panel.

We look forward to today's testimony. Your statements will be made a part of the record and you may summarize the statements or you may read them verbatim, however you so desire.

[A biographical sketch of Mr. Aldridge follows:]

EDWARD C. ALDRIDGE, JR.

Mr. Edward C. "Pete" Aldridge Jr. is the under secretary of the Air Force. He conducts Air Force affairs on behalf of the Secretary of the Air Force, at the Secretary's discretion and in his absence. Additionally, he provides overall direction, guidance and supervision for Air Force space programs and space activities.

Mr. Aldridge was born Aug. 18, 1938, in Houston and spent his youth in Shreveport, La. He received a bachelor of science degree in aeronautical engineering from Texas Agricultural and Mechanical University in 1960, and a master of science degree, also in aeronautical engineering, from the Georgia Institute of Technology in 1962.

Prior to joining the Department of Defense in 1967, Mr. Aldridge held various staff and managment positions in the Douglas Aircraft Company, Missile and Space Division in Santa Monica, Calif., and in Washington, D.C.

In 1967 he joined the staff of the assistant secretary of Defense for systems analysis as an operations research analyst and then seved as director of the Strategic Defensive Division until July 1972. He also served as an adviser to the Strategic Arms Limitation Talks in Helsinki and Vienna.

He re-entered private industry in 1972 as a senior manager with LTV Aerospace Corporation in Dallas for a year until he was named senior management associate in the Office of Management and Budget, Executive Office of the President, Washington, D.C.

Returning to the Department of Defense in February 1974, Mr. Aldridge served as deputy assistant secretary of Defense for strategic programs until March 1976. He was then selected to be the director of planning and evaluation, a principal adviser to the secretary of Defense in the planning and program evaluation of U.S. military forces and support structure.

He was named vice president, National Policy and Strategic Systems Group for the Systems Planning Corporation, Arlington, Va., in March 1977. Mr. Aldridge was responsible for the corporation's study and analysis activities in the strategic, naval, tactical nuclear, chemical weapons, arms control and long-range strategic planning areas. He assumed his present duties in August 1981.

His work in various assignments has earned him numerous awards. Among these are the Secretary of Defense Meritorious Civilian Service Award, Department of Defense Distinguished Civilian Service Award and Department of Defense Distinguished Public Service Award.

Mr. Aldridge is married to the former Joanne Knotts of Italy, Texas. They have four children.

STATEMENT OF EDWARD C. ALDRIDGE, UNDER SECRETARY OF THE AIR FORCE, DEPARTMENT OF THE AIR FORCE, ACCOMPANIED BY DR. CHARLES COOK, DEPUTY ASSISTANT SECRETARY FOR SPACE PLANS AND POLICY; MAJ. GEN. BERNARD RANDOLPH, DIRECTOR OF SPACE SYSTEMS AND COMMAND AND CONTROL COMMUNICATIONS, HEADQUARTERS, USAF; AND MAJ. GEN. JOHN STORRIE, DIRECTOR OF SPACE, OFFICE OF THE DEPUTY CHIEF OF STAFF FOR OPERATIONS, HEADQUARTERS, USAF

Mr. ALDRIDGE. Thank you, Mr. Chairman.

I am delighted to have this opportunity to speak to this committee on the space activities on which the Air Force and NASA are working together.

I am accompanied today by Dr. Charles Cook, who is the Deputy Assistant Secretary for Space Plans and Policy in the Secretariat of the Air Force; Maj. Gen. Bernie Randolph, the Director of Space Systems and Command and Control Communications at Headquarters, U.S. Air Force; and Maj. Gen. John Storrie, the Director of Space under the Deputy Chief of Staff for Operations, also the Headquarters of Air Force.

Mr. Chairman, you asked that I address five topics in my presentation, the first of which is our current evaluation of the progress of the shuttle; our joint activities with NASA on the space transportation system; our plans for the shuttle and expendable launch vehicles; the status of the Air Force role in a manned space station; and, finally, the status of the Air Force Space Command.

I have provided detailed information on these topics in my formal statement, but what I would like to do this afternoon is to summarize those topics for you, just to highlight our position on each specific subject.

First, with regard to our evaluation of the shuttle program, we are pleased with the shuttle program and anticipate continued success. We are, of course, monitoring closely the STS-6 developments but do not feel that the problems are fundamental or of sufficient concern to change our commitment to the shuttle. We are continuing to plan for the first dedicated STS launch of a DOD payload in November of 1983.

DOD's partnership with NASA in the shuttle program is most graphically demonstrated by the construction of a shuttle launch facility at Vandenberg Air Force Base in California. We are about 80 percent complete in the construction of the facilities, and our major effort now is focused on the installation and checkout of the equipment that goes into that facility. We are still on schedule for the first shuttle launch from Vandenberg in October of 1985.

We have also joined with NASA to seek a common shuttle processing contract at Kennedy and Vandenberg, in order to achieve the economies of operation in a continuing effort to reduce the shuttle launch cost.

I would like now to turn to the joint program activities between NASA and the Air Force. As you know, the primary purpose of Vandenberg is to give shuttle users access to the high inclination and polar orbits. We use the Kennedy site to launch satellites to the lower inclination and to geosynchronous orbits.

To boost these satellites from the shuttle orbit altitudes to about 22,000 miles, which is the geosynchronous altitude, requires carrying a specially designed upper stage in the shuttle bay, and we have two joint upper stage programs with NASA. The inertial upper stage, which is called IUS, was developed by the Air Force but it is used by NASA and the Air Force. Most recently we have a Centaur upper stage which is being jointly developed and will be used by NASA and the Air Force.

Last year, after Congress directed that NASA use the Centaur for the Galileo and Solar Polar missions, we in the Air Force felt that the Nation could benefit from a joint effort and we signed a memorandum of understanding with NASA on this effort on November 9 of this past year, 1982. This joint program is proceeding quite well. We are currently planning to use the Centaur for three national security spacecraft, with first launch in 1987. As you know, the Galileo and Solar Polars are planned for 1986.

In addition, NASA and the Air Force recently signed a new agreement on shuttle pricing policy. In principle the Air Force has agreed to pay NASA the same price per launch as NASA would charge a civil or commercial user or a foreign government—and this is exclusive of a prorated share of manpower costs that we share between our agencies—and to do so in a way which will minimize the turbulence caused from DOD-induced schedule changes. We have agreed to launch cost increases from $16 million to $29.8 million, measured in fiscal year 1975 dollars, our base for comparison. This new pricing arrangement adds over $2 billion to the NASA budget over the next 5 years from the DOD budget.

The DOD, with the Air Force acting as its executive agent for launch operations, is fully committed to use the shuttle as our primary launch vehicle. In fact, many of our satellites are now designed only for the shuttle. That is, they are no longer capable of

being launched from expendable boosters. Many others, while they are dual/compatible, will no longer have expendable launch vehicles to act as backup to the shuttle.

We have continued to follow the national policy established several years ago which directs that we backup the shuttle for 2 years at Kennedy and for 1 year at Vandenberg. We have Titan III-D's in this backup role. We plan no more backup capability after this period I have just mentioned, and are considering termination of the Titan production line this year.

At the same time, we have had several unsolicited proposals to commercialize expendable launch vehicles such as the Titan, the Atlas, and the Thor/Delta. We are encouraging such proposals, but must point out that the actual commercialization provisions are subject to specific policy guidelines now being formulated by the administration. We continue to be hopeful that such a commercialization venture will be successful. We believe that it really is in the best interest of the country.

You have also asked our position on a fifth orbiter. The President has recently made a decision, which we strongly support, that maintains the option of making a future decision on procurement of replacement orbiters. This means we will maintain the orbiter production base, to include items such as wings, midbodies, and crew modules. If a four-orbiter fleet continues to meet the Nation's requirements, the production base components can be used as modular spares. However, if demand or circumstances dictate additional or replacement orbiters, the production base will be in place to support such a decision. We are quite satisfied with this approach.

You also asked about the Air Force role in space station activities. The Air Force has been and is an active participant in the studies of a manned space station. We are investigating many proposals to determine if there are any unique contributions a manned space station can make to our national security needs.

We want to be sure that the study efforts will be comprehensive and thorough enough to insure that we are not overlooking a valuable mission. At this point we are not prepared to endorse any specific application, but there is still a lot of analysis yet to be done.

Finally, Mr. Chairman, you asked that I address the status of our newest Air Force major command, the Space Command. The Space Command was activated on September 1, 1982, in Colordo, Springs, Colo. Space systems and the organizational elements are now in the process of transferring to this command. We expect the Space Command to be fully operational later this year.

There are several reasons we created the Space Command. These include the need to provide an expert center to which Air Force commanders could express their requirements for space systems, a center which could act in an informed advocacy role. Also, we needed an organization to focus our study of and response to Soviet military space activities. We needed to provide a closer link between the development and acquisition of space systems, on the one hand, and the day-to-day operations of spacecraft on the other hand, and we hope to demonstrate our major commitment to this important area for support of our national security goals.

However, we have not really completed our efforts with Air Force Space Command. It is our hope and anticipation that the

Space Command will evolve into a unified or specified command in the future, therefore serving the needs of all of the services and providing a direct, unambiguous operational command line for assigned space assets from the Secretary of Defense through the Joint Chiefs of Staff.

Mr. Chairman, I would like to address one other issue that has been raised subsequent to the creation of the Air Force Space Command, and that is the mistaken notion that somehow the United States is militarizing space. Evidence for such assertions is usually cited as the growing space budget in the Department of Defense, or references to vague scenarios involving weapons in space.

Nothing could be more misleading. The growing DOD space budgets are dictated by many factors, one of which I mentioned earlier regarding the $2 billion increase in the shuttle launch charges which DOD must reimburse NASA over the next few years. Aside from that, we have discovered that doing business in space is just more cost effective for many of the support functions. There is no better way to do communications, meteorology, warning of attack, and surveillance than from space platforms.

With regard to weapons in space, the Soviets have been the sole nation to deploy weapons in space. They started in the 1960's when they developed and tested an orbital bombardment system, and they also now have an operational co-orbital type antisatellite system which has been under test for over a decade.

The United States, on the other hand, has never placed a weapon in orbit and has no approved programs to do so. We do use space systems to provide timely and accurate information to decisionmakers, to reduce political and military uncertainty, monitor provisions of international treaties, provide warning against attack, and better utilize our forces against a numerically superior enemy. Therefore, in my judgment there is only one nation involved in militarizing space, and it is not the United States.

In conclusion, Mr. Chairman, we believe our space programs and the formation of a space command are major steps which will provide an enhancement of our national objectives of deterrence of hostilities and the creation of a more stable, peaceful global environment.

Thank you, Mr. Chairman. I am ready to answer any questions you may have at this time.

[The prepared statement of Mr. Aldridge follows:]

STATEMENT OF

HONORABLE EDWARD C. ALDRIDGE

UNDER SECRETARY OF THE AIR FORCE

Mr. Chairman, I am delighted to have this opportunity to talk to your Committee on those space-related issues where we, the Air Force, and NASA are working closely together. I am accompanied today by Dr. Charles Cook, the Deputy Assistant Secretary of the Air Force for Space Plans and Policy; by Major General Bernard Randolph, the Director of Space Systems and Command, Control and Communications at Headquarters U.S. Air Force; and by Major General John Storrie, the Director of Space, Deputy Chief of Staff for Operations, at Headquarters U.S. Air Force.

Since I last had the pleasure of addressing this Committee, we have witnessed the completion of the highly successful Space Shuttle Orbital Flight Test Program and we have seen a nearly flawless flight on the Shuttle's first operational mission. Based on this demonstrated performance, we can now look confidently forward to a new and exciting national capability that will significantly effect future space activities. Of course, as is always the case in such a complex development program, a number of questions still remain unanswered and we must still overcome some troublesome problem areas.

Today I will cover the following items in response to the questions that I was specifically asked to address:

- Our evaluation of the Shuttle program to date

- Our activities with NASA on developing the Space Transportation System (specifically the Vandenberg and Centaur programs)
- Our plans for use of the Shuttle and the companion question of the future of Titan launch vehicles
- The status of the Air Force role in a future manned space station
- And, finally, status of the Air Force Space Command.

This Nation is vitally dependent on space systems, both militarily and within the civil sector, and this dependence is increasing. Fundamental to this dependence is having a flexible, robust, and affordable means of delivering payloads on orbit. In 1972, this country decided to build a system that would meet these criteria and the Space Shuttle Program was born.

Because of the costs associated with developing the Shuttle, it was decided that the Shuttle should be a National capability and become the nation's primary means of launching spacecraft. This meant that the Shuttle had to be a reliable, flexible system that could meet national launch demands.

We have been very pleased with the Shuttle's flight test program and its highly successful first operational mission. We are justifiably proud of the design,

development and progress to date of the Shuttle. Thus far, the fastest turnaround for a Shuttle launch was for STS flight four, which took 78 workdays for Orbiter refurbishment and maintenance. With additional experience and maturing of the system hardware, this turnaround time should decrease appreciably. Indeed the turnaround must decrease in order to increase the Shuttle launch rate, which is a key element in driving Shuttle launch costs down.

We are still concerned, however, whether the Shuttle will be able to launch the payload weights that were specified in the early days of Shuttle development. We have some national security payloads being developed which are close to the latest maximum payload-weight projections provided by NASA. Reductions in Orbiter payload weight capability could cause significant problems, and result in serious delays and cost increases for some of the nation's most critical spacecraft.

We are also closely monitoring the schedule slip of the upcoming flight of STS-6 (the first Shuttle launched Inertial Upper Stage and the first Tracking and Data Relay Satellite), because of the possible effect on the future

Shuttle launch schedule. While we do not believe the slip will delay our first DOD dedicated flight, STS-10, it does create some uneasiness regarding the Shuttle operational capabilities during its current early operational period.

The current problems with the Space Shuttle Main Engines (SSME) are troublesome and disruptive, but I believe they are part of the learning phase associated with bringing any new, complex system into operation. These SSME problems are also indicative of the importance of the long standing question concerning the adequacy of the logistics support provided for the Shuttle. Time and additional STS flight experience will improve our ability to predict the number and type of spare parts required. For example, it is now evident, to both NASA and the Air Force, that the STS program does not currently have an adequate supply of SSMEs. I am pleased that Lt General Abrahamson has already started a program to procure additional SSME assets.

Fortunately, the current slip in schedule happens as we are just building up to our planned Shuttle launch fleet capability. Such a delay later, when more traffic is scheduled for flight, would be far more serious.

With just five STS flights to date, there is not yet adequate data to make a reasoned and confident decision on orbiter fleet size. As additional flights are made, we will

be able to assess more fully such critical factors as turn-around time, system availability, maintenance, attrition, and demand. Sound and prudent management dictates that all STS production capabilities be maintained until we have made solid assessments of these critical factors. To constrain ourselves prematurely to a four Orbiter fleet may erode confidence in the STS as a reliable and dependable space transportation system. Both U.S. and foreign commercial customers must be able to view the STS as a dependable approach in obtaining a firm launch schedule. Significant launch delays translate rapidly into economic penalties that are particularly significant to commercial users. It is important that the STS be operated as it was conceived making it highly dependable and competitively priced as rapidly as possible.

Thus, I strongly support maintaining the President's policy on the option of making a future decision on procuring replacement Orbiters. This means we should maintain the Orbiter production base to include such items as wings, mid-bodies, and crew modules. If a four Orbiter fleet continues to meet the nation's requirements, the production base components can be used as modular spares. However, if demand

or circumstances dictate additional or replacement Orbiters, the production base will be in place to support such a decision under efficient conditions.

In a related area, I am pleased to inform the Committee that the Air Force has renegotiated Shuttle user charges with NASA. The new price of $29.8 Million after 1985 (in 1975 dollars) has been incorporated in our FY 1984 budget request. This upward adjustment was made to set more fairly user charges and it will help guarantee the viability of the Shuttle program as the nation's primary launch vehicle. The key element of this agreement was the determination of a fair charge for DOD launches. The DOD will pay the same price for launch as commercial users for equivalent service, excluding manpower charges which will be traded between the Air Force and NASA. This agreement supports Congressional interest in keeping the Shuttle adequately supported without eroding other elements of the NASA budget. It also ensures that government agencies pay no more for Shuttle launches than commercial users or foreign countries.

Part of DOD's participation in the National Shuttle Program is the development of Shuttle processing, launch, and landing facilities at Vandenberg AFB, California. This development is proceeding towards a first launch in October 1985. This West Coast Space Shuttle facility will permit

civil and government Shuttle users access to polar and near-polar earth orbits. Polar orbits cannot be reached from the Kennedy Space Center launch site without significant performance loss necessary to avoid overflying densely populated areas.

Vandenberg Shuttle launch and landing construction was started in FY 1979 with substantial modifications and additions to a launch pad that was built for the now-cancelled Manned Orbiting Laboratory program. A number of major construction projects are underway. These consist of facilities needed to store and process the Orbiter, the external tank, the solid rocket boosters, and the payloads during pre-launch assembly and checkout activities. Also included are off-line engineering, data processing, and logistics support facilities. Construction is about 80 percent complete. The Shuttle Assembly Building construction project awarded this past January is the last time-critical, major facility construction effort. This construction is on the critical path for an October 1985 IOC.

With many of the major buildings and facilities having been erected, the major efforts have now transitioned to equipment and systems installations. This is the critical phase of the development program and will require the best efforts on the part of the Vandenberg team to meet the

schedule. We have devoted significant management attention to the Vandenberg program and have an able and competent team managing it. We believe that the Vandenberg construction will be completed on the time schedule required.

This critical need for Vandenberg combined with mutual NASA/AF interest in assuring the most economical operations possible, prompted the two agencies to join together in requesting industry to propose a single Shuttle Processing Contract for both coasts. This single contract approach will not only provide for healthy competition but will also give the winning contractor team maximum flexibility to earn the substantial incentives being offered for increased efficiency and reduced costs. This is only one of several positive signs of the maturing of the STS program.

All in all, we are pleased about the progress being made at Vandenberg. Mr. Chairman, I would like to invite you and your Committee to visit the facilities to observe the accomplishments and to see in detail how we plan to process and launch the Space Shuttle there.

The Vandenberg launch site is used for spacecraft requiring polar or near-polar orbits. Most of these spacecraft will be placed in low-earth orbits wherein most of the Shuttle payload capacity is translated into spacecraft payload on orbit. The Kennedy launch site is used to launch

spacecraft requiring lower inclination orbits including all of our geosynchronous high altitude spacecraft. Since these spacecraft require altitudes greater than that achievable by the Shuttle, a boost propulsion stage must be used to place the spacecraft in the desired orbit. Use of this boost stage, which must be considered as part of the Shuttle payload, results in a significant reduction in the spacecraft weight that can be placed in higher altitude orbits.

These Shuttle compatible upper stages are critically important in the amount of payload that can be placed in higher orbits. In examining national security upper stage requirements last year, it became apparent that the Inertial Upper Stage (IUS) was close to the margin required to meet the near-term projected weight needs and that a higher performance upper stage would be necessary by the late eighties. When NASA was directed by Congress, during the FY 1983 review process, to develop an STS compatible Centaur upper stage to launch its Galileo and Solar Polar space missions, we decided that a joint development program between the DOD and NASA would be in the nation's best interest. Thus, NASA and the DOD will cost share the basic development program, called Centaur G. NASA will fund required modifications for the Shuttle and launch pad as well as fund a stretched version of the stage called Centaur G

prime. Under this agreement, two Centaur G vehicles are needed by DOD to meet our 1987 and 1988 mission needs. A third spacecraft program, already integrated to the IUS will transition to the Centaur as part of a planned spacecraft block change in the late 1980s. Our remaining spacecraft programs will remain on the IUS for the near term since these spacecraft are not scheduled for block changes until the early 1990s and earlier transition to Centaur would be too costly. I believe this upper stage strategy of continuing the IUS program while transitioning certain programs to the Centaur gives us the flexibility and capability needed to meet our future mission requirements.

Mr. Chairman, the development of the Centaur is a success-oriented schedule for both NASA and DOD. We are using the existing Atlas Centaur avionics with no major redesign and no technology dependent developments. The most significant problem we face deals with Centaur interface problems between the Orbiter and the payloads. I would emphasize that the NASA and DOD Centaur programs are interrelated as is the funding. Any changes in either the NASA or DOD funding profile for Centaur will impact the overall Centaur development for both agencies.

As you know, the President on July 4, 1982 announced a National Space Policy which reaffirmed the Space

Transportation System as the primary space launch system for both national security and civil government missions. That policy emphasizes that our first STS priority is that it become fully operational, reliable and cost-effective. The policy also provides, for continuation of expendable launch vehicles until we have confidence that the demonstrated capabilities of the STS are able to meet all the scheduled and performance requirements of our national security spacecraft.

The DOD strategy for transitioning payloads to the Shuttle is consistent with the National Policy and calls for acquisition of sufficient backup Titan vehicles to ensure a launch capability for our critical DOD missions. The current backup policy was approved several years ago and provides for expendable launch vehicle (ELV) launch resources for the first two years of Shuttle operations from the Kennedy launch site and for one year of operations from the Vandenberg launch site. The backup capability will be provided by the newly developed Titan III(34)D boosters.

DOD's strong commitment to the STS is evidenced by a Defense budget for Shuttle development, operations and related costs (Titan backups, CSOC, and payload transition) which exceeds $15B through FY 1988. Air Force planning for

the Shuttle includes the transition of all national security spacecraft from their current expendable launch vehicles (Titan, Atlas, Thor/Delta) to the Shuttle by FY 1989. With the exception of one program (DMSP), the transition will actually be completed by the end of FY 1986. Through FY 1987, the Air Force has reserved 14 of the first 70 Shuttle flights as dedicated missions for DOD payloads. I wish to emphasize, however, that in some critical programs we have already optimized our spacecraft for the Shuttle and as such, we can no longer fly these on current expendables; thus the Shuttle has now become a truly essential element of our national defense posture.

All in all, our transition plan is working well. We developed the Titan III(34)D to provide a common booster for all of our payloads to use -- both at the East and West Coast launch sites -- during the transition period. We also developed the IUS to provide a common Shuttle and ELV compatible stage so Shuttle backup could be readily achieved. The first launch of the Titan III(34)D/IUS combination took place in October 1982 and placed both satellites into extremely precise mission orbits. We expect the IUS will provide similar performance with the NASA Tracking and Data Relay Satellite on STS-6.

We are nearing the decision point of continuing the Titan ELV production program. We will decide, following STS-6, if Shuttle performance will meet our essential national security needs. If STS-6 is successful, we would not expect to proceed with a long lead procurement of material for the 17th and 18th Titan III(34)D vehicles. Such action would end Air Force procurement of the Titan since we would have an adequate number of Titan vehicles built or in production to meet our launch needs through the Shuttle transition period.

There is considerable contractor activity in trying to obtain approval for the commercial production and launch of ELVs. The Administration currently has the ELV commercialization subject under study, and we need detailed policy considerations before the Air Force can negotiate agreements with the various contractors for use of launch and range facilities. I believe there are benefits to the Government which warrant our support of this venture. We would obtain a measure of Shuttle backup without continued government investment as well as a reduction in ELV termination costs to the Air Force.

Looking into the future, we are now examining AF and DOD requirements which could necessitate a permanent manned presence in space. We are actively

participating in NASA activities and working with eight contractors in studying space station needs, attributes, and architectural options. We are also supporting through DOD the Senior Interagency Group (SIG) Space-Station Working Group in addressing the issue of what policy issues must be identified and resolved in order to establish the basis for an Administration decision on whether to proceed with development of a permanently based, manned space station. In addition, the Air Force Scientific Advisory Board (SAB) has recently initiated a study of the potential military utility of a manned space station. The SAB will provide an independent appraisal of the potential military utility of a possible national space station to assist in determining the appropriate level, if any, of AF/DOD participation and involvement in the program.

However, I would caution on moving into a new large space initiative before the Shuttle is truly operational. The cost savings originally projected that would result from developing a reusable system as opposed to using ELVs has simply not yet materialized. I believe both NASA and DOD must work hard in the near future to reduce Shuttle costs. Much can be done in this regard, but it is going to require extensive effort by our best people to bring these reductions to fruition.

Mr. Chairman, you also requested that I provide you information on the Air Force's Space Command (SPACECOM).

SPACECOM was officially established as the Air Force's newest major command on 1 September 1982, with its headquarters located in Colorado Springs, Colorado. The transfer of systems from other Air Force commands to SPACECOM is currently underway.

Several converging factors led to the creation of a Space Command.

SPACECOM is the natural response to the growing national security demands on an evolving and expanding military space program. From within the military came the pressure of a growing recognition of the dependence that we have on space systems and a better understanding of the "force multiplier" effect that space systems contribute in countering, to some degree, the great quantitative advantage that the Soviets have. From the Soviets came the pressure of a growing threat and an aggressive military space program with an operational anti-satellite system. Finally, from this Administration came the significant steps of a new space policy directive that we maintain the nation's leadership in space and to use that preeminence to strengthen national security.

The sum of these pressures led to the formation of SPACECOM.

- To place space systems into the established military command structure and allow operational Commanders to use familiar methods and avenues to access space capabilities.
- To centralize the organizational response to the Soviet threat to our space program so that a clear and cogent voice can be heard both as an advocate for needed responses and as an advisor to the national command authority.
- To demonstrate the Air Force's commitment to this nation's new and most welcome space policy.

Space Command is, therefore, both a recognition of the changing nature of the military space program and a promise of things to come. It was created because it was time to formalize the operational contribution of space systems and because such an organization will be essential in meeting the future challenges to our national security and the threat to the free and peaceful world that we all hope for.

As stated in the public announcement to form SPACECOM, it is the hope and belief of the Air Force that SPACECOM will quickly evolve to become a unified command.

Once SPACECOM is fully operational and functioning as a Major Command, the Joint Chiefs of Staff will examine the unified command issue in more detail.

Mr. Chairman, I would like to address one other issue that has been raised subsequent to the creation of the Air Force Space Command. This is, the mistaken notion that somehow the United States is "militarizing space". Evidence for such assertions, is usually cited as the growing space budget in DOD, or reference to vague scenarios involving weapons in space. Nothing could be more misleading....

Larger space budgets are dictated by many factors -- such as the one billion dollar increase in Shuttle launch charges which DOD must reimburse NASA over the next few years. Aside from that, we have discovered that doing business in space is just more cost effective for many support functions. There is no better way to do communications, meteorology, warning, and surveillance than from space platforms.

Now with regard to weapons in space, the Soviets have been the sole nation to deploy weapons in space. They started in the 1960s when they developed and tested an orbital bombardment system. And they also now have an operational co-orbital type anti-satellite system which they have been testing for over a decade.

The United States on the other hand has never placed a weapon in orbit and has no approved programs to do so. We do use space systems to provide timely and accurate information to decisionmakers, to reduce political and military uncertainties, monitor provision of international treatiies, to provide warning against attack, and to better utilize our military forces against a numerically superior enemy. In our judgment there is only one nation actively seeking to militarize space and it is not the United States.

In conclusion, Mr. Chairman, we believe our space efforts and the formation of the Space Command are major steps which provide an enhancement of our national objectives of deterrence of hostilities and a more peaceful, stable, global environment.

This concludes my formal statement, Mr. Chairman. I will be pleased to accept any questions the Committee may have.

Mr. VOLKMER. Thank you very much, Secretary Aldridge. I have several questions. We may have some we will have to submit also for the record.

Mr. ALDRIDGE. Yes, sir.

Mr. VOLKMER. What is the total cost of the inertial upper stage full-scale development contract?

Mr. ALDRIDGE. I can't give you the exact number but, roughly, it is $700 million, which is the full-scale engineering development and the procurement of eight upper stage systems, sir.

[The information follows:]

The Interial Upper Stage Full Scale Development contract which includes the development of the standard two stage IUS, the now cancelled planetary IUS variant, and the initial eight IUS flight vehicles plus long lead parts for a ninth vehicle is expected to complete at $738M.

Mr. VOLKMER. How does this compare with your original estimated cost?

Mr. ALDRIDGE. It is about a factor of three over the original estimate.

Mr. VOLKMER. Are the DOD Milstar and the NASA 30–20 gigahertz communication technology programs being coordinated?

Mr. ALDRIDGE. I would like to ask General Randolph if he would answer that question. He is very familiar with that issue.

General RANDOLPH. Yes, sir. What we are presently doing, we have several contracts in which we and NASA are jointly sponsoring those contractual efforts, and we do coordinate on the contractual efforts that NASA has uniquely and that the Air Force has uniquely. Therefore, the answer is yes, sir, we are.

Mr. VOLKMER. OK. Now will the technology developed in the MILSTAR program be available for commercial use?

General RANDOLPH. Yes, sir, in the following sense: In that when we do technology development, the industry, of course, does that work for us. They have that knowledge available to them to apply to commercial use. One example of that is that in one particular company, the satellites now being developed and built for the Intelsat consortium use the kind of technology that we, the DOD, actually developed. Therefore, the answer is yes, sir, indirectly.

Mr. VOLKMER. In other words, you paid for the development of that technology by the same people that are now utilizing it.

General RANDOLPH. That is correct. Yes, sir.

Mr. VOLKMER. Would the Air Force have any objection if private sector companies attempted to commercialize a version of the inertial upper stage?

Mr. ALDRIDGE. No, sir. Commercialization, of course, has been established as a goal in the President's national space policy, and we certainly support that direction. So long as we can make sure we protect the national security interest, we have no objection to that type of capability being commercialized. In fact, we are supporting the commercialization of the Titan and other expendable launch vehicles as being in the Nation's interest.

Mr. VOLKMER. Now you mentioned in your statement you had some concerns about the shuttle being able to deliver the payloads that are going to be necessary in the future.

Mr. ALDRIDGE. Yes, sir.

Mr. VOLKMER. Have you discussed this with NASA?

Mr. ALDRIDGE. Yes, sir, every day, just about, sir.

Mr. VOLKMER. All right. Are——

Mr. ALDRIDGE. They are fully aware of our problems and we both are working to——

Mr. VOLKMER. Well, I think everybody is aware of the problem of getting to 109 percent.

Mr. ALDRIDGE. Yes, sir.

Mr. VOLKMER. However, as I understand it, even though they have delayed some of the testing now, they still plan to proceed and they will have a time frame in which they can work to get there before it is needed.

Mr. ALDRIDGE. Yes, sir. I have talked to Dr. Mark about this, in fact just as recently as last week, and he assures me that the plan is being worked. Our requirements are in the late 1985, early 1986 period, and he assures me that there is a program plan laid out to ensure that we have the performance that is necessary to meet our critical payloads.

Mr. VOLKMER. Can you elaborate at all on the Air Force's view in regard to the number of orbiters which are, in your view, needed for the future? I am talking about 1987, 1988, 1989, and 1990.

Mr. ALDRIDGE. Yes, sir. Because the Department of Defense, in which the Air Force, of course, acts as the executive agent—we have planned over the next 5 years to fly about 20 percent of the planned orbiter flights and over the next 10 years, about 30 percent of the orbiter flights—we feel in the Department of Defense that so long as we maintain a viable four-orbiter fleet with the necessary spare parts and the facilities to turn it around at the proper times, and so forth. Because our needs are somewhat limited we feel the four-orbiter fleet is sufficient to meet the Department of Defense needs.

However, we are concerned with looking at it from a national perspective, whether or not that is going to be sufficient from an overall point of view. We can certainly meet our requirements and we can establish our national security priority over any user, and it may require that they throw off some of the commercial users off of some of the orbiter flights in order that we meet them, if we ran into a problem of the overhaul periods taking longer than we thought or the turnaround times taking longer than we thought, or that we did not have sufficient spare parts to fix the failed parts on the orbiter, so that we could not meet all of our national requirements.

Therefore, we strongly supported the idea of maintaining, one, a viable four-orbiter fleet, and maintaining the option to buy additional orbiters. We know that the four orbiters will not last forever. We will need replacement capabilities, and so while there may be some argument of when those capabilities might be required into the future, we felt we needed to maintain the production base to support additional orbiter procurement in the future. We were quite happy with the President's decision to maintain the production base by providing those spare parts to maintain the viable orbiter, and also the option to continue production.

Mr. VOLKMER. You have mentioned that you are participating in the study for a space station concept or permanency in space.

Mr. ALDRIDGE. Yes, sir. We have actually contributed funds to support the NASA effort in that.

Mr. VOLKMER. Now approximately how much are you contributing on that?

Mr. ALDRIDGE. We provided $300,000 of the $6 million—I believe it was $6 million—that NASA contributed, to insure that the national security interests were in fact being looked at in that particular activity.

Mr. VOLKMER. Now what is the Air Force view on the need for man in space on a permanent basis, and the need for a space station capability?

Mr. ALDRIDGE. Well, the position that we are taking at this point in time, I guess I would classify as cautious optimism. We do not know exactly what role man can contribute in addition to the capabilities which already exist. We have not taken a position for or against a space station for support of national security needs, but we feel that we need to continue to look at this area in a comprehensive and thorough manner so that we are sure we are not overlooking some obvious capability. However, right now we have no position other than to continue to monitor the activity that exists in NASA and continue to support that.

Mr. VOLKMER. In the event that the studies show and those in responsible positions come to a conclusion that we should pursue a permanency in space, a space station——

Mr. ALDRIDGE. Yes, sir?

Mr. VOLKMER [continuing]. Who should be in charge of the development, NASA or the Air Force?

Mr. ALDRIDGE. NASA, sir.

Mr. VOLKMER. Thank you.

Now you have already addressed Vandenberg, and that is on schedule——

Mr. ALDRIDGE. Yes, sir.

Mr. VOLKMER [continuing]. You will be ready to go, come 1985.

Mr. ALDRIDGE. We are heading down that direction with great pace, and as far as we know right now we have no insurmountable problems. It is a very difficult task; there is no question about it. It is a very complex task. So long as we do not run into any unknown problems at this time, I think we will be on schedule.

However, we do recognize that every time we launch one of these orbiters, we learn something, and we have to incorporate changes into the launch capability. We do that in a responsive manner at Vandenberg. Therefore, assuming we continue with our known problems now, we will be on schedule for 1985, October of 1985.

Mr. VOLKMER. Do you have any formal position in regard to extending the time of the present astronauts that are now in the service? In other words, what about if NASA extended some of the current astronauts a couple of years?

Mr. ALDRIDGE. Sir, we do not have any formal position on that. Maybe someone here could answer. I am not aware of any.

Mr. VOLKMER. Has that possibility been brought to your attention? From discussions that this committee has had with the people in Houston, down at Johnson, you will run into a problem in the 1985, possibly 1986 timeframe.

Mr. ALDRIDGE. We have a policy by which we can extend people if it is in the best interest of the Nation and the Air Force. On the other side of the coin, I think the people in the Air Force would feel like they would really like to utilize those talents that are coming out of NASA for support of the Air Force main program.

Mr. VOLKMER. Well, that is the reason for part of the question, because some of those people may like to get back into the basic Air Force uniform, rather than staying with NASA. You have not really studied this issue.

[The information follows:]

The assignment of Air Force personnel to the National Aeronautics and Space Administration (NASA) is governed by Department of Defense Directive 1000.17, Department of Defense Personnel Assigned to Duty Outside the Department and Supporting Non-DOD Activities, and by Air Force Regulation 30-19, Air Force Personnel Assigned to Duty Outside the Department of Defense and Supporting Non-DOD Activities. The assignment of Air Force personnel to non-DOD agencies is rigorously controlled at all Air Force management levels. The Air Force will consider all requests for assignment extensions from NASA on a case-by-case basis. Each case would be forwarded with an Air Force recommendation to the Assistant Secretary of Defense (Manpower, Reserve Affairs, and Logistics) for a final decision. Individual career development, individual retainability and availability, individual desires and interests of the DOD are just a few of the numerous factors that must be taken into consideration before making a decision.

Mr. ALDRIDGE. No, sir. It has not been brought to my attention that that has created a problem so far. We do have a policy by which we can review—that is a pretty specialized area—on those cases we can review those on a case-by-case basis and we can in fact extend them if it is in the best interests of the country to do so.

Mr. VOLKMER. Looking at that, do you have any plans for the Air Force—and I am sure it would not be Army or Navy, probably, but mostly the Air Force—developing a program to train astronauts itself?

Mr. ALDRIDGE. Yes. We have programs in being right now where we are training mission specialists for some of the DOD flights. They are astronauts but they will not be the commander or the pilot; they will be mission specialists.

Mr. VOLKMER. Are you working with NASA on those?

Mr. ALDRIDGE. Yes, sir.

Mr. VOLKMER. Do you foresee any Air Force or military requirement for extending the period of time for the orbiter to be in space? In other words, right now they usually have 5 to 7 days. Do you see anything that would require that you should be up there 14, 20 days?

Mr. ALDRIDGE. I am not aware of any missions that we have in the future, within the foreseeable future, that would require any additional time on orbit. It could be that as a result of these studies for the manned space station, there may be some things we could identify for some experiments that might do that, but right now I do not foresee any.

Mr. VOLKMER. I did a calculation in my head, based on your testimony that DOD has 20 percent of the payloads——

Mr. ALDRIDGE. Of the 70 shuttle missions currently planned for the next 5 years, we will fly 14 of those; and then through 1993, I

think the number is in the order of 315 and we will fly about 30 percent of those. Over the next 10 years we will fly about——

Mr. VOLKMER. Yes, but will those be evened out or will those—other words, 30 percent over 10 years, if you put them all in 1 or 2 years that takes them all.

Mr. ALDRIDGE. No, sir, they will be averaged out.

Mr. VOLKMER. I mean, are those going to be basically averaged out?

Mr. ALDRIDGE. Yes, sir. No way could we afford to fly all those in any given year.

Mr. VOLKMER. I have no further questions.

Buddy, do you have any questions?

Mr. MCKAY. No, Mr. Chairman.

Mr. VOLKMER. All right. We will be submitting some questions for the record.

Thank you very much.

Mr. ALDRIDGE. Yes, sir. Thank you.

Mr. VOLKMER. I appreciate your testimony here today.

We will now proceed and hear from Mr. Van Reeth.

Mr. Van Reeth, your statement will be made a part of the record, and you can either summarize or review the statement in total. I see you are accompanied by Mr. Mellors. Is that correct?

Mr. VAN REETH. Yes, sir.

Mr. VOLKMER. You may proceed at this time.

[A biographical sketch of Mr. Van Reeth follows:]

GEORGE PETER VAN REETH

George Peter Van Reeth (58) has a Ph. D. in Law from the University of Louvain (Belgium). He further studied Political Science at "L'Ecole des Sciences Politiques: in Paris. He is currently Director of Administration of the European Space Agency (ESA), Paris (appointed in April, 1975).

Mr. G. VanReeth, after some time in private law practice, joined NATO. In 1964 he was appointed Assistant Director of Contracts at the European Space Research Organisation (ESRO), Space Technology Establishement in the Netherlands (ESTEC). From 1972 until 1975, he was the Administrative Director of the European Launcher Development Organisation (ELDO), Paris.

STATEMENT OF GEORGE Van REETH, DIRECTOR OF ADMINISTRATION, EUROPEAN SPACE AGENCY, ACCOMPANIED BY MR. MELLORS

Mr. VAN REETH. Thank you, sir.

The Director-General of the European Space Agency, sir, wishes me to express to the subcommittee his appreciation of being invited once more to appear as a witness and his regrets at not being able to do so in person. He has also asked me to say that he will be happy to provide written answers to any additional questions that your committee may wish to put to him, and of course I will be very pleased to answer orally any questions you may wish to put to me.

Mr. Chairman, for the benefit of the new members of the subcommittee, my testimony this year incorporates a review of the agency's programs which are purely European as well as those specifically mentioned in your letter of invitation. With your permission, I will submit the whole testimony for the record but today

will only mention those matters of particular interest to your committee.

As in previous years, I wish to start by stating categorically that ESA and its member states remain fully committed to the principle of international cooperation in space activities and, in particular, cooperation with the United States of America.

I will first deal with the spacelab, which as you know is the largest cooperative space program ever undertaken, and which has been described as the finest gift Europe has made to the United States since the Statue of Liberty. The delivery of the first spacelab flight unit to Kennedy Space Center at the end of 1981 was followed in the spring and summer of 1982 by the delivery of the European payload element, comprising some 55 experiments, for the first flight, and of the spacelab hardware units for the second flight.

Level 4 integration of the ESA and NASA payloads has now been completed, and the complete spacelab 1 payload is currently being integrated into the spacelab. Integration of the spacelab into Columbia's cargo bay will start in mid-July of this year.

ESA and NASA nominated the prime and backup payload specialists for the spacelab 1 mission in September of last year. ESA has assigned Dr. Ulf Merbold of Germany as the prime and Dr. Wubbo Ockels of the Netherlands as a backup. Together with their American counterparts, they are now undergoing simulation training.

The first flight of spacelab is currently scheduled for September 30 of this year. In view of the many previous delays, we are naturally anxious that the delays experienced by the orbiter, *Challenger,* do not impact upon the spacelab flight. NASA is keeping us fully apprised of the situation and our relations with General Abrahamson and other members of the NASA staff are excellent. We are confident that everything possible will be done to maintain the date and to insure a successful mission. Nevertheless, until *Challenger* flies and TDRSS is operating satisfactorily, we will inevitably be somewhat apprehensive.

The production of a second set of spacelab hardware, which is being purchased by NASA from ESA, is proceeding steadily. Approximately 75 percent will have been delivered by the end of this year. The program is comfortably within budget and the relations between NASA, ESA, and the industrial teams are excellent.

In April 1982 participating member states approved the start of the spacelab follow-on development program, the main component of which is the development of a European retrievable carrier—[Eureca]—to be launched and retrieved by the space shuttle. Eureca is a reusable payload carrier with its own power supply, attitude control, and other subsystems, that will be capable of staying on orbit for 6 months or more. At the end of its mission, it will be retrieved by the shuttle and returned to Earth where it will be refurbished and prepared for the next flight.

The program has been funded at something in excess of $120 million, the baseline configuration has been established, and the phase A definition study will be completed by June of this year. As far as possible, we will use already developed hardware, and as a result are sufficiently confident that we have paid NASA $100,000 ear-

nest money for the first flight on STS–55 in April 1987. The retrieval will be effected by STS–63 in September of the same year.

I believe that this carrier offers good possibilities for further United States-European cooperation, and we are discussing this with our NASA friends. At the same time, we are also keenly interested in the studies being carried out by NASA on the utilization of, and the requirements for, a manned space station, and we are grateful to NASA for the opportunity to follow the progress of these studies.

In turn, we have initiated similar studies in Europe and have invited NASA to attend a review of these studies in April of this year. As I will indicate later, these studies form part of a comprehensive assessment of the future direction of European activities in space transportation which was approved by the council a few months ago.

Turning to the Ariane program, as I am sure you are aware, the program suffered a setback in September of last year when two agency satellites—Marecs–B and Sirio–2 —were lost due to the failure of the launch L–5. The cause of the failure was due to a malfunction of a turbo pump in the third-stage engine.

The next launch, allocated to ECS–1, the first European operational communications satellite, and an amateur radio satellite—[Amsat]—has now been set for June 3, 1983. All being well, the next three launches, each with an Intelsat 5 satellite, will take place in August and November 1983 and January 1984.

As I said earlier, Mr. Chairman, the agency is in the process of assessing what should be its role in space transportation in the next 10 to 15 years. To this end, the council has approved some $9 million for a series of studies which will cover three main areas.

These are, one, what should be done in the field of expendable launchers after Ariane 4? Two, what is Europe's interest in manned space station activities, and what, if the opportunity presented itself, should Europe's participation in a NASA space station program be? Should such a program receive congressional approval, of course?

What activities, third, should Europe undertake in the field of what we term "on-orbit infrastructure"? For the moment, this is mainly development of technology for such techniques as automatic rendezvous and docking, automatic assembly, refueling and servicing of large spacecraft in geostationary orbit, intersatellite communication links, and teleoperator maneuvering systems.

If you will allow me, I would now like to turn to space science. Our next scientific satellite, Exosat, is ready to be launched on a Delta vehicle from the Western Test Range at the end of May, this year. Exosat was due to be launched by Ariane in November of last year, but because of the failure of L–5 this had to be postponed. The delay was such that there was doubt whether it would be possible to effect a launch during the 1983 summer window, and at the same time fears were growing for the integrity of the scientific payload. I wish, therefore, to take this opportunity to express our appreciation of the NASA offer of a Delta launch.

The development of the ESA satellite for the International Solar Polar Mission is proceeding as planned. The satellite is nearly complete, and when finished will be placed in storage. We have noted

the decision to proceed with development of the Centaur upper stage for this mission, and are looking forward to a launch in May of 1986.

We also understand that there is a problem, which may be only procedural, over the provision of funds to enable NASA to modify the shuttle launch pads to accommodate the Centaur. Perhaps it is worth noting, Mr. Chairman, that the original planned launch date for the two ISPM spacecraft mission was this month, and hence any further delay would be more than disappointing to Europe.

The development of ESA's hardware contribution to the space telescope is proceeding, and we expect to deliver the various engineering and flight models of the solar array and the faint object camera to NASA on the currently agreed dates. We are also well on the way toward completing our selection of scientists and engineers who will form our contribution to the space telescope Institute, and the first few have already arrived in Baltimore.

As we intend to deliver our hardware contributions to NASA as soon as they are complete, any further delay in the launch date of the space telescope will not affect ESA's hardware costs. However, the need to maintain in being the technical and scientific teams—including that at STI—for a longer period will, I fear, inevitably increase our total cost. At the same time, we fully appreciate the magnitude of NASA's task in developing such a complex and advanced instrument.

We have now let the hardware contract for the GIOTTO spacecraft, which is the European mission to Halley's Comet. We have made arrangements with NASA to use the deep space network as a backup facility to receive telemetry from the spacecraft during the encounter phase.

Looking somewhat further into the future, the agency is about to embark on a study of some seven scientific missions, of which one or possibly two will be selected in about 18 months from now. Of these two, a mission to Saturn and its satellite Titan and a spaceborne very long base interferometer seem especially suitable for international cooperation, and we are in the process of initiating working level discussions with NASA on the technical possibilities.

Finally with regard to space science, I would like to say that in recognition of NASA's very open policy in the matter of foreign participation in its projects, it has been decided that in the future ESA's projects will be opened under similar conditions to the U.S. space science community.

For remote sensing, last year the Joint Research Center of the European Economic Community—the EEC—and the agency submitted a proposal to NASA for the validation of Landsat 4 data to be received by our stations at Fucino in Italy and Kiruna in northern Sweden. The program was approved by NASA and has obtained some very promising results. Unfortunately, it cannot proceed now unless a means is found to restart the X-Band transmissions from the satellite. We sincerely hope this will be the case, as we believe that the thematic mapper has already demonstrated its value and excellence.

ESA's own remote sensing satellite program, ERS-1, was started in May of 1982, and the final decision to proceed with the hardware development will be taken at the end of 1983. The primary

mission of ERS–1 will be the monitoring of the ocean and the polar icecaps, although it is also planned to collect data over land with the C-Band synthetic aperture radar that forms one element of the payload, the other items being wind and wave scatterometers, an altimeter, and a scanning radiometer

Finally, in the field of remote sensing we are discussing with our member States the initiation of an Earth observation preparatory program which would pave the way for an ERS–2. If this were approved, there may be a possibility that this spacecraft could carry a U.S. instrument.

In conclusion, Mr. Chairman, I would like to repeat what I said earlier, that ESA and its member States remain fully committed to the principle of cooperation with the United States in space activities. We believe that, especially in times of financial stringency, international cooperation is essential to carrying out important programs with limited resources. Further, I believe that the history of the past years has demonstrated that such cooperation does provide significant mutual benefits to the partners.

I hope that my testimony today has indicated that there are, and will continue to be, similar opportunities for the future. Finally, as space activities mature and more countries embark upon their own programs, it is inevitable that the exploration and utilization of space will have more and more international implications, and that a nation's space policy will become an important element of its foreign policy. For all of these reasons, Mr. Chairman, I believe it behooves the United States and Europe to cooperate to the greatest practical extent.

Thank you for listening.

[The prepared statement of Mr. Van Reeth follows:]

Statement by Mr. George Van Reeth, Director of Administration
EUROPEAN SPACE AGENCY

The Director General wishes me to express to the Subcommittee his appreciation at being invited, once more, to appear as a witness, and his regrets at not being able to be here in person. He has also asked me to say that he will be happy to provide written answers to any additional questions that the Subcommittee may wish to put to him and, of course, I will be very pleased to answer orally any questions you may wish to put to me now.

Mr. Chairman, for the benefit of the new members of the Subcommittee my testimony this year incorporates a review of the Agency's programmes which are purely European as well as those specifically mentioned in your letter of invitation. With your permission I will submit the whole of the testimony for the record but today will only mention those matters of particular interest to the Subcommittee.

As in previous years I wish to start by stating categorically that ESA and its Member States remain fully committed to the principle of international co-operation in space activities and, in particular co-operation with the United States.

I will deal first with Spacelab which as you know is the largest co-operative space programme ever undertaken and which has been described as the finest gift Europe has made to the U.S. since the

Statue of Liberty. The delivery of the first Spacelab flight unit to KSC at the end of 1981 was followed in the spring and summer of 1982 by the delivery of the European payload element (comprising some 55 experiments,) for the first flight,and of the Spacelab hardware units for the second flight.

Level IV integration of the ESA and NASA payloads has now been completed and the complete SL-1 payload is currently being integrated into the Spacelab. Integration of the Spacelab into Columbia's cargo bay will start in mid-July of this year.

ESA and NASA nominated the prime and back up Payload Specialists for the SL-1 mission in September of last year. ESA has assigned Dr. Ulf Merbold of Germany as the prime and Dr. Wubbo Ockels of the Netherlands as back up. Together with their American counterparts, they are now undergoing simulation training.

The first flight of Spacelab is currently scheduled for September 30th of this year. In view of the many previous delays we are naturally anxious that the delays experienced by the Orbiter, Challenger, do not impact on Spacelab's flight. NASA is keeping us fully appraised of the situation and our relations with Gen. Abrahamson and other members of the NASA staff are excellent. We are confident that everything possible will be done to maintain this date and to ensure a successful mission. Nevertheless, until Challenger flies and TDRSS is operating satisfactorily,, we will inevitably be somewhat apprehensive.

The production of the second set of Spacelab hardware, which is being purchased by NASA from ESA, is proceeding steadily. Approximately 75% will have been delivered by the end of this year. The programme is comfortably within budget and the relations between NASA,ESA and industrial teams are excellent.

In April 1982 participating Member States approved the start of the Spacelab Follow-On Development Programme, the main component of which is the development of a European Retrievable Carrier (EURECA) to be launched and retrieved by the Space Shuttle. EURECA is a re-usable payload carrier with its own power supply, attitude control, and other subsystems, that will be capable of staying on orbit for 6 months or more. At the end of its mission it will be retrieved by the Shuttle and returned to Earth where it will be refurbished and prepared for the next flight. The programme has been funded at something in excess of $120 millions, the baseline configuration has been established and the Phase A definition study will be completed by June of this year. As far as possible we will use already developed hardware, and, as a result, are sufficiently confident that we have paid NASA $100,000 earnest money for a first launch on STS-55 in April 1987. The retrieval will be effected by STS-63 in September of that year.

The advantages of such a free flying carrier are, of course, its ability to remain in orbit for much longer than the Orbiter and its very low levels of gravity and contamination. EURECA will be first used for a microgravity mission, which forms part of the EURECA programme. EURECA will, however, be suitable for many other applications such as astro and solar physics, earth observations, technology demonstrations and space manufacturing. I believe this carrier offers

good possiblities for further US/European co-operation and we are discussing this with NASA.

At the same time we are also keenly interested in the studies being carried out by NASA on the utilisation of, and requirements for, a manned space station and we are grateful to NASA for the opportunity to follow the progress of these studies. In turn we have initiated similar studies in Europe and have invited NASA to attend a review of these studies in April of this year. As I will indicate later, these studies form part of a comprehensive assessment of the future direction of European activities in space transportation, which was approved by the Council a few months ago.

In January 1982 the Agency took a further step in its proposed utilisation of Spacelab. This was the approval of a Microgravity Programme. This programme will involve the development of multi-user experimental facilities for use on Spacelab, to enable studies to be carried out in the fields of life science and materials science. Microgravity research using sounding rockets will also be undertaken.

Turning to Ariane, the programme, as I am sure you are aware, suffered a set back in September of last year when two Agency satellites, MARECS-B and SIRIO-2 were lost due to a failure of launch L5. The cause of the failure was due to the malfunction of a turbo-pump in the third stage engine.

The recommendations of the Failure Enquiry Boards have now been implemented; improved turbo pump gears and a modified lubrication system will be incorporated into all pumps in the future. The next launch, allocated to ECS-1, the first European operational communications satellite, and an Amateur Radio Satellite (AMSAT), has now been set for June 3rd, 1983. All being well the next three launches, each with an Intelsat V satellite, will take place in August and November 1983 and January 1984.

The development of Ariane 2 and Ariane 3 is proceeding uneventfully and the first launch of an Ariane 3 will occur with L-10 in March 1984. Similarly the 2nd Ariane launch facility is progressing towards its planned completion and commissioning in October 1984. Civil engineering work has been completed, and work has started on the installation of electrical, pneumatic and hydraulic systems which are expected to be completed by end 1983.

The first launch from this pad is scheduled for the 1st quarter of 1985.

Last year we reported that the Ariane 4 programme had recently been approved. This is now proceeding and when complete will provide a family of six launchers, based on a single basic vehicle, which will span a performance range in geostationary transfer orbit from 2,000 to 4,200 kilogrammes, ie: slightly less than that of the two stage I.U.S. The qualification flight is scheduled for late 1985 and once

qualified, we will be able to stop production of Arianes 1,2 and 3. As there will be only one basic vehicle, we expect Ariane 4 launch costs to be significantly less than those of the earlier models.

As I said earlier, Mr. Chairman, the Agency is in the process of assessing what should be its role in Space Transportation in the next ten to fifteen years. To this end the Council has approved some $9 millions for a series of studies which will cover three main areas. These are :-

1) what should be done in the field of expendable launchers after Ariane 4 ?

2) what is Europe's interest in manned space station activities and what, if the opportunity presents itself, should Europe's participation in a NASA space station programme be - should such a programme receive Congressional approval ?

3) what activities should Europe undertake in the field of what we term "on orbit infra structure". This is mainly the development of technology for such techniques as automatic rendezvous and docking, automatic assembly, refuelling and servicing of large spacecraft in geostationary orbit, intersatellite communication links and teleoperator manoeuvring systems.

I would now like to turn to Space Science.

First, it was with considerable regret that last April the Agency had to switch off COS-B which had an originally planned life of two years but which operated successfully for almost seven years. The mission has produced outstanding results in the field of gamma ray astronomy.

Our other two scientific satellites in orbit, GEOS-2 and ISEE-2 have continued to perform well. Our ground station at Madrid for the IUE satellite has also continued to obtain excellent results and proposals for its use far exceed the available observation time.

Our next scientific satellite, EXOSAT, is ready to be launched on a Delta vehicle from the Western Test Range at the end of May. EXOSAT was due to be launched by Ariane in November of last year, but, because of the failure of L5, this had to be postponed. The delay was such that there was doubt whether it would be possible to effect the launch during the 1983 summer window and, at the same time, fears were growing for the integrity of the scientific payload. I wish, therefore, to take this opportunity to express our appreciation of NASA's offer of a Delta launch.

The development of the ESA satellite for the International Solar Polar Mission is proceeding as planned. The satellite is nearly complete and when finished will be placed in storage. We have noted the decision to proceed with the development of the Centaur upper stage for this mission and are looking forward to a launch in May 1986. We also understand that there is a problem, which may only be

procedural, over the provision of funds to enable NASA to modify the Shuttle launch pads to accommodate the Centaur. It is perhaps worth noting that the originally planned launch date for the two spacecraft ISPM mission was this month, and, hence any further delay would be more than disappointing to Europe.

The development of ESA's hardware contribution to the Space Telescope is proceeding and we expect to deliver the various engineering and flight models of the solar array and Faint Object Camera to NASA on the currently agreed dates. We are also well on the way towards completing our selection of scientists and engineers who will form our contribution to the Space Telescope Institute (S.T.I.) and the first few have already arrived in Baltimore. As we intend to deliver our hardware contribution to NASA as soon as they are complete, any further delay in the launch date of the Space Telescope will not affect ESA's hardware costs. However, the need to maintain in being the technical and scientific teams (including that at the S.T.I.), for a longer period will, I fear, inevitably increase our total costs. At the same time we fully appreciate the magnitude of NASA's task in developing such a complex and advanced instrument.

We have now let the hardware contract for the GIOTTO spacecraft which is the European mission to Halley's Comet. We have made arrangements with NASA to use the Deep Space Network as a back up facility to receive telemetry from the spacecraft during the encounter phase.

By agreement with the Australian authorities we are arranging to modify the Parkes Radio Telescope near Canberra to be the primary telemetry receiver during this phase and we are now engaged in tripartite negotiations which will result in the modified telescope also being used as a telemetry receiver during the VOYAGER-2 encounter with URANUS in 1986.

The last of our approved space science satellites is Hipparcos, which is an astrometry mission, which will obtain the position, inclination and true velocity of some 100,000 stars. The Announcement of Opportunity requesting proposals for the observation catalogue has been sent to the U.S. astronomical community.

ESA's next scientific mission will be selected by the Science Programme Committee later this month. At the moment there is a field of five but the recommendation of our Science Advisory Committee is for an Infra Red Observatory (ISO) which would be launched about 1990 and which would be a natural evolutionary step beyond IRAS, the joint Dutch/UK/US satellite which was successfully launched last month.

Looking somewhat further into the future the Agency is about to embark on the study of some seven scientific missions from which one (or possibly two) will be selected in about 18 months from now. Of these, two, a mission to SATURN and its satellite TITAN, and a space borne Very Long Base Interferometer seem especially suitable for international co-operation and we are in the process of initiating working level discussions with NASA on the technical possibilities.

Finally with regard to space science I would like to say that in recognition of NASA's open policy in the matter of foreign participation in its projects it has been decided that, in future, ESA's projects will be open, under similar conditions, to the U.S. space science community.

Remote Sensing

Last year the Joint Research Center of the European Economic Community and the Agency submitted a proposal to NASA for the validation of Landsat 4 data to be received by our stations at FUCINO in Italy, and KIRUNA in Northern Sweden. The programme was approved by NASA and has obtained some very promising results. Unfortunately, it now cannot proceed unless a means is found to restart the X-Band transmissions from the satellite. We sincerely hope this will be the case as we believe the Thematic Mapper has already demonstrated its value and excellence.

ESA's own remote sensing satellite programme, ERS-1, was started in May of 1982 and a final decision to proceed with the hardware development will be taken at the end of 1983. The primary mission of ERS-1 will be the monitoring of the oceans and the polar ice caps, although it is also planned to collect data over land with the C-Band Synthetic Aperture Radar that forms one element of the payload; the other items being wind and wave scatterometers, an altimeter and a scanning

radiometer. Finally in the field of remote sensing we are discussing with our Member States the initiation of an Earth Observation Preparatory Programme which would pave the way for an ERS-2. If this were approved, there may be a possibility that this spacecraft could carry a U.S. instrument.

Conclusion

In conclusion, Mr. Chairman, I would like to repeat what I said earlier, that ESA and its Member States remain fully committed to the principle of co-operation with the U.S. in space activities. We believe that, especially in time of financial stringency, international co-operation is essential to carrying out important programmes with limited resources. Further, I believe, that the history of the past years has demonstrated that such co-operation does provide significant mutual benefits to the partners. I hope that my testimony today has indicated that there are and will continue to be similar opportunities for the future. Finally, as space activities mature and more countries embark on their own programmes, it is inevitable that the exploration and utilisation of space will have more and more international implications and that a nation's space policy will become an important element of its foreign policy. For all these reasons, Mr. Chairman, I believes it behoves the U.S. and Europe to co-operate to the greatest practical extent.

Mr. VOLKMER. Thank you very much, Mr. Van Reeth.

As a sidelight, I might say that some of us who traveled to Huntsville and were there on Monday had the good fortune of meeting both Dr. Merbold and Dr. Ockels while they were going through some of the testing down there with the space lab.

Does the gentleman from Florida have any questions?

Mr. MACKAY. I have a question but I am not certain that I know enough to even ask it intelligently. If you will forgive me, I will just ask the question, as a new member.

I understand that your Ariane program has in some ways functioned competitively with the space shuttle program in this country. It seems to me, with the record of coordination otherwise, that this is something of an exception. How do you see that whole——

Mr. VAN REETH. Sir, Ariane launches satellites; the shuttle launches satellites; the expendable vehicles in the United States launch satellites. It is obvious that there is a certain amount of competition.

I find as long as it is open commercial competition, where people try to compete with each other honestly, this is not a problem. The competition that worries me more is one that is based on a certain amount—on both sides, I am not saying the United States particularly, on both sides—on a rather intransigent and intolerant nationalistic attitude, which I personally deplore no matter where it goes on, whether it is in Europe or in the United States. I think minorities in both continents are sometimes guilty of this, yes, but as far as commercial competition goes, if it remains a fair competition, why not? I think Europe and the United States compete and try to get clients in many commercial fields.

Mr. MACKAY. Thank you.

Mr. VOLKMER. The next flight of the Ariane will be in June?

Mr. VAN REETH. June 3, sir.

Mr. VOLKMER. Well, as I understand your testimony, there appears to have been good cooperation between ESA and NASA in the past. Do you see any reason why that should not continue?

Mr. VAN REETH. Certainly not at this moment, sir. I have personally had 20 years with the agency, so I have lived through the history of this. We have had excellent cooperation with NASA.

We have had difficulties. We have had the difficulties on I3PM, which are well known, we have had other difficulties. They have all been solved, and at this moment it is really clear weather. We have no problems and we have a very good understanding on most issues.

Mr. VOLKMER. Do you foresee in the future, also, continued commitment by your member countries to ESA?

Mr. VAN REETH. Yes, sir, definitely.

Mr. VOLKMER. Now as I understand it, you are preparing for a Halley's Comet mission.

Mr. VAN REETH. Yes, sir.

Mr. VOLKMER. Is there any participation by NASA on that?

Mr. VAN REETH. Yes, we will have one piece of hardware on board that is being developed by NASA. We have many U.S. coinvestigators of the experiments on the GIOTTO spacecraft with whom we have good cooperation. Also, as I said in my testimony, we use as a backup the deep space network.

Mr. VOLKMER. Just out of curiosity, being a new member also along with the gentleman from Florida, what type of experiments are you going to utilize on the Halley's Comet Mission?

Mr. VAN REETH. Sir, may I refer the question to Mr. Mellors? He is much more competent to say this. I am an administrator.

Mr. VOLKMER. Sure, more the technical aspects of it.

Mr. MELLORS. I think it would be better, Mr. Chairman, if we sent you a list of the experiments.

Mr. VOLKMER. That would be fine.

Mr. MELLORS. We can also, with that, give you a list of the American coinvestigators.

Mr. VOLKMER. That would be fine. I would appreciate that.

[The information follows:]

esa

european space agency
agence spatiale européenne

The Hon. Harold L. Volkmer,
Chairman,
House Subcommittee on Space Science and Applications,
U.S. House of Representatives,
Washington D.C. 20515

Monday 14th March, 1983 181-2/356

Dear Mr. Chairman,

GIOTTO, Mission to Halleys Comet Scientific Payload

In response to the question posed to Mr. Van Reeth at the Subcommittee hearing on March 2nd, 1983, I am now pleased to provide further information on the objectives and scientific payload of ESA's mission to Halley's comet.

As indicated in the testimony the main objectives of the mission are to :

1) obtain images of the nucleus of the comet
2) assess the chemical composition of the coma
3) investigate the plasma in the neighbourhood of the comet.

To this end the payload includes a camera, three mass spectrometers, plasma experiments and a magnetometer, in all there will be ten experiments on board, eight of these having U.S. co-investigators. In one instance, that of the ion mass spectrometer, a significant contribution to the experimental hardware is being made by Dr. Neugebauer of J.P.L.

I am enclosing with this letter brief details of each experiment together with a list of the U.S. scientists who are participating in the project.

I trust that this will provide all the information you require but if this is not the case, please do not hesitate to contact me again.

Yours sincerely,

W.J.Mellors
Head, Washington Office.

955 L'Enfant Plaza, Washington, D.C. 20024, Tel. : 202.488.4158 - Telex : ESA WASH. 64412

TABLE 1.1 CURRENT PAYLOAD RESOURCE ALLOCATION

PI	INSTRUMENT	MASS (KG)	POWER	NOMINAL TLM RATE (bs^{-1}) FORMAT 1	FORMAT 2	FORMAT 3
Keller (MPAe)	Halley Multi-Colour Camera	11.48	12.2	20058	20058	723
Krankowksy (MP-Kern)	Neutral Mass Spectrometer	10.94	10.1	4156	4156	N.A.
Balsiger (Univ. Bern)	Ion Mass Spectrometer	8.76	9.5	3252	3252	1084
Kissel (MP-Kern)	Particulate Impact Analyser	10.0	11.6	2891	5782	N.A.
McDonnell (Univ Kent)	Dust Impact Detection System	2.0	1.9	361	903	N.A.
Reme (CESR)	Reme Plasma Analyser	2.85	3.7	2530	1807	904
Johnstone (UCL)	Johnstone Plasma Analyser	3.08	4.2	3975	1265	1355
Levasseur-Regourd (S.A. France)	Halley Optical Probe Experiment	1.1	1.2	723	723	N.A.
McKenna-Lawlor (St. Patricks College, Eire)	Energetic Particle Admonitor	0.5	0.7	181	181	181
Neubauer (Braunschweig)	Magnetometer	1.25	1.2	1265	1265	407
TOTAL		52.96	56.3	39392	39392	4654

NOTES:

1. Total Payload Allocations including margin: 56.1 kg, 62 watts, 39392 bs^{-1}

2. Format 3: Pre-encounter (-24hrs) science + cruise phase subject to operational constraints
   Format 1: Encounter + 3hrs science - plasma orientated.
   Format 2: Close encounter - dust orientated.

Mr. VOLKMER. Now I believe you also said the second set of Spacelab hardware is almost completed?

Mr. VAN REETH. It will be 75 percent delivered within this year, sir, and the rest of it in the beginning of next year. It is on schedule.

Mr. VOLKMER. Everything is on schedule, and you have no problems with that part of the program at all?

Mr. VAN REETH. No, sir. In fact, one hardly hears about it, which means that there are no great problems.

Mr. VOLKMER. Now up on the conclusion of the Spacelab flights 1, 2, 3, do you foresee any future development in that area?

Mr. VAN REETH. Yes, sir. First of all, we would like to mention that there is a second European mission planned which is really a German national mission, a major part of which will be Europeanized and handled by the agency. That is the D-1 mission. I believe there will be many more missions, particularly after spacelab has flown once. We must not forget that spacelab has been around for a long time and it has been a long time since the original plan was made.

Mr. VOLKMER. Right.

Mr. VAN REETH. People will get much more enthusiastic again once there has been one flight and they have seen it at work.

Mr. VOLKMER. Once you get the information back as to how the experiments are working and everything, then you anticipate——

Mr. VAN REETH. Yes, sir. We are also planning, as Mr. Mellors points out to me, we have started a microgravity program which, of course, will use spacelab and the shuttle.

Mr. VOLKMER. How do you view the idea of permanency in space? What is ESA's basic view of that?

Mr. VAN REETH. Sir, we have no definitive view on that. That is why, like NASA, we are doing a study on what could possibly be, the utilization of a space station on a European scale. What would the use be? What would it look like?

I think if we can prove that it has use and that it is something to do, that Europe would be keen to cooperate in such a program.

Mr. VOLKMER. You are still looking during what I call the definitive stage, also, then?

Mr. VAN REETH. Yes, sir.

Mr. VOLKMER. Do you have any timetable as to making a determination on that?

Mr. VAN REETH. No, sir. We really have no firm timetable, it is over the coming 1½ to 2 years, that we will do all these studies — but of course our timetable depends a lot on what the U.S. timetable is going to be, because we do not conceive to do this on our own.

Mr. VOLKMER. Right.

Mr. VAN REETH. If we do this at all, we will do it in cooperation, and so we are a little bit dependent on how the NASA studies go.

Mr. VOLKMER. Are you participating in any extent in the NASA studies that are presently ongoing?

Mr. VAN REETH. We are kept fully informed. We follow the results and NASA follows the results of our studies. In fact, as I said, in April of this year we are going to have a presentation of the European studies which will be attended by NASA personnel there.

Mr. VOLKMER. On land sensing, you mentioned in your statement that because of the problems with the X-Band nobody is able to get any transmission from the Thematic Mapper. However, what about the other, the MSS? Have you been receiving signals continuously, participating in that?

Mr. VAN REETH. Yes, sir, and on the previous landsats also.

Mr. VOLKMER. Yes. When the TDRSS goes up and starts operating, then of course you will be able to—through White Sands, I suppose, somehow—be able to get the TM also.

Mr. VAN REETH. Yes, sir, I believe that is being planned.

Mr. VOLKMER. Right.

Does the gentleman from California have any questions?

Mr. LOWERY. No, Mr. Chairman.

Mr. VOLKMER. I have no further questions. I wanted to thank you very much for coming, and look forward to continued cooperation in space exploration and utilization.

Maybe one last question: Do you believe that the ESA would be interested, in the event that the studies show a space station need—whether it be manned or unmanned or whatever—do you believe that ESA would wish to cooperate with NASA in developing such a station or stations?

Mr. VAN REETH. The ultimate decision would depend on the opinion of our member states but, in practice, I can almost be certain, yes, sir, but of course there would have to be a formal decision by the member states to participate; but there is great interest.

Mr. VOLKMER. Right. In other words, there is a lot of interest in it?

Mr. VAN REETH. There is a lot of interest. We consider that Eureca is a first step that could go toward the use of platforms in space, and space stations.

Mr. VOLKMER. You are planning to send it up——

Mr. VAN REETH. In 1987.

Mr. VOLKMER [continuing]. In 1987?

Mr. VAN REETH. April of 1987.

Mr. VOLKMER. Very good. Thank you very much, Mr. Van Reeth. We appreciate very much your being here.

We will now hear from Mr. Willis M. Hawkins, who is Chairman of the Aerospace Safety Advisory Panel.

Mr. Hawkins, your statement will be made a part of the record and you may either summarize or review the statement in full.

Maybe before you begin it would be best to identify the persons who are at the table there with you, for the record.

[A list of the panel and staff and a biographical sketch of Mr. Hawkins, Mr. Parmet, General Davis, Mr. Grier, and Mr. McDonald follows:]

PANEL AND STAFF

Willis M. Hawkins, Chairman, Senior Advisor, Lockheed Corporation.
Richard H. Battin, Associate Department Head, Charles Stark Draper Lab., Inc.
Leighton I. Davis, Retired Lt. Gen., USAF, Consultant.
Gerard W. Elverum, Jr., Vice President-General Manager, TRW Space and Technology Group.
Herbert E. Grier, Former Sr. Vice President EG&G, Inc., Consultant.
Seymour C. Himmel, Retired Assoc. Director, NASA LeRC, Consultant.

Ira Grant Hedrick, Presidential Asst. for Corp. Technology, Grumman Aerospace Corporation.
John F. McDonald, Former Vice President—Technical Services, TigerAir, Inc.
Norman R. Parmet, Former Vice President TWA, Consultant.
John G. Stewart, Assistant General Manager, Tennessee Valley Authority.
Robert D. Rothi, Retired Chief Design Eng. Douglas Aircraft, Consultant.
Stanley I. Weiss (Ex-Officio), NASA Chief Engineer, NASA Headquarters.
Gilbert L. Roth, Staff Director, NASA Headquarters.
Susan Webster, Advisory Committee Assistant, NASA Headquarters.

Willis Moore Hawkins

Mr. Willis Moore Hawkins, Jr., born in 1913, graduated from University of Michigan in 1937 with a B.S. degree in aeronautical engineering. He received an honorary Doctor of Engineering degree from the University of Michigan in 1965, and an honorary Doctor of Science degree from Illinois College in 1966.

Mr. Hawkins began his career with Lockheed in 1937 as an engineering draftsman; 1944 engineering department manager; 1949 chief preliminary design engineer; 1953–1957 director of engineering at Lockheed Missiles and Space Division; 1959 was appointed assistant general manager of that division; 1960 vice president of Lockheed Corporation and 1962 vice president science and engineering. In 1963, Mr. Hawkins served as Assistant Secretary of the Army for Research and Development. He returned to Lockheed in 1966, and in 1969 was advanced to senior vice president science and engineering of Lockheed Corporation and then president of the Lockheed Aircraft Corporation in 1978. He is presently senior advisory of Lockheed Corporation.

He received distinguished Civilian Service Awards in 1965 and 1966 from the Army, has authorized many company proposals and technical reports, headed numerous special governmental task groups and is a member of Riverside Reseach Institute, National Academy of Engineering and a fellow of the American Institute of Aeronautics and Aerospace, and many others.

Mr. Hawkins is married to the former Anita E. Stanfill and they have three children. Their home is in Encino, California.

Norman R. Parmet

Mr. Norman R. Parmet, born October 28, 1920, received his BSME from Drexel Institute of Technology in 1947.

Mr. Parmet was squadron engineering officer and instructor pilot in command of B–17 and B–29 aircraft from 1943 to 1946 in the U.S. Army Air Force. He then joined Trans World Airlines in August 1947 as power plant engineer, as supervisor in 1953 he was the first engineer in TWA to have responsibity for evaluation of the then new gas turbine engine and for recommending the type of engine to be selected for new jet aircraft. He directed the aircraft development group, coordinated development of new aircraft specifications, construction and acceptance from 1956 until 1962. He was Vice President Equipment Development (1962–1971); Vice President Quality Assurance (1971 thru 1973). Vice President, Materials Management and Procurement (1973–1978), and Vice President for Engineering and Quality Assurance (1978–1981) responsible for (1) engineering, (2) technical development, and (3) quality assurance.

He has been elected to many honorary societies and received numerous awards including Pi Tau Sigma, Van Renesselaer Scholarship. He is a member of such societies as AIAA, SAE, IATA as well as many civic and social organizations. He has had many technical papers published.

Mr. Parmet is married to Jean and they have three children. They currently reside in Fairway, Kansas.

Gen. Leighton Ira Davis

Lt. Gen. Leighton Ira Davis USAF (Ret.), born in 1910, received his B.S. degree in 1935 from U.S. Military Academy and M.S. degree in 1941 from Massachusetts Institute of Technology, an honorary Doctor of Laws from New Mexico State University in 1961 and an honorary Doctor of Space Science in 1965 from Florida Institute of Technology.

Lt. Gen. Davis begn his military assignment in 1935 as a pilot; from 1936–1938 he was engineering officer with the Six Pursuit Squadron Hawaii, and from 1939–1943 he was an instructor at the U.S. Military Academy, West Point, New York. The period from 1943–1960 Gen. Davis was assigned to various high risk/technology USAF research and development programs. He became Commander, Air Force Missile Test Center in 1960 and National Range Division, USAF in 1946; then in 1967–1968 Commandant, Industrial College of the Armed Forces. He retired from USAF in 1968.

His civilian experience was with Lockheed Aircraft Corporation from 1968–1975 as Corporate Director of Product Safety where he directed and monitored safety activities of Lockheed's many divisions and subsidiary companies. He retired from Lockheed in 1975.

Lt. Gen. Davis received the Legion of Merit twice (U.S. Army and USAF), the Thurman H. Bane Award, NASA Medal for Outstanding Leadership, and the NASA Distinguished Service Medal. He is a fellow of the American Institute of Aeronautics and Astronautics, and a fellow of the International Academy of Astronautics.

Gen. Davis and his wife reside in Albuquerque, New Mexico.

Herbert Earl Grier

Mr. Herbert E. Grier, born July 1911, earned both his Bachelor of Science and Master of Science degrees in Electrical Engineering (1934) at MIT.

In 1937 Mr. Grier with Dr. Edgerton and Mr. Germeshausen continued their work in ultra high speed photography and development of unique stroboscopic and flash lighting techniques. This work led to an M.I.T. project for the improvement of aiming techniques for aircraft armament, and the use of electronic flash photogaphy for night aerial reconnaissance by the Army Air Force.

The partners incorporated to form Edgerton, Germeshausen & Grier, Inc., now known as EG&G, Inc. in 1947. Mr. Grier was EG&G's first president. He then became involved in atomic weapons research for the Manhattan Engineering District, its successor the AEC (now the Department of Energy).

In 1953 he came to Las Vegas, Nevada to direct a group of EG&G scientists assigned by the AEC to support its nuclear test operations. Since then the company has designed, built and operated the equipment that has armed, timed, fired, photographed and acquired performance data on almost every nuclear test blast in the Pacific and Nevada. They also provided instrumentation and photographic support for nuclear rocket tests. Mr. Grier was also President and Chairman of Reynolds Electrical & Engineering Co., the support services contractor at the Nevada Test Site from 1969 until 1971.

Until his retirement in 1976, Mr. Grier was President of CER Geonuclear Corporation, a company formed in March 1965 by Continental Oil Company, EG&G, Inc., and several other companies. CER's was concerned with the development and implementation of methods of using the power of nuclear explosives in commercial applications.

Mr. Grier is the current Chairman of the Aerospace Safety Advisory Panel of NASA.

Mr. Grier is Chairman of the National Advisory Board of the University of Nevada's Desert Research Institute.

Mr. Grier received an honorary Doctorate of Science in 1967 from the University of Nevada and holds registered professional engineering licenses in Colorado, Massachusetts and Nevada. He has numerous patents and publications, both classified and unclassified.

Mr. Grier and his wife reside in La Jolla, California.

John Fraser McDonald

Mr. John Fraser McDonald was born June 17, 1917. After graduating as a mechanical engineer in 1938 and serving an apprenticeship at Westland Aircraft Co., Ltd, United Kingdom, he joined British Overseas Airline Corporation (BOAC) as an aero-designer in 1940. During World War II he was in charge of a design and development group working on military/commercial aircraft. Following the war he was placed in charge of an engineering group supporting the new post-war North Atlantic commercial service of BOAC. He was Chief Technical Officer, Western Division, BOAC at the time he joined Lockheed Aircraft Corp., Burbank, CA in 1952 where he headed the maintenance and logistics group. In 1957 he was named Service Division Engineer involved in the C–130 Hercules, F–104 Starfighter, L–188 Electra, P3A

Orien, L-1011 and other aircraft. Through the summer of 1967 he managed a variety of disciplines including reliability, maintainability, safety, human engineering, ground support equipment, airport compatibility as head of the Systems Assurance Division. In 1967 he moved to the Flying Tiger Line as Vice-President, Maintenance and Engineering. He is currently the TigerAir, Inc. Vice-President for Technical Services. During this time he has modernized the maintenance systems and fleet reliability/safety rates which are among the best in the industry.

McDonald is a Chartered Engineer on the U.K. Register and a Fellow of both the Royal Aeronautical Society and the Society of Licensed Aircraft Engineers and Technologists. He is an Associate Fellow of the AIAA, a Member of the Institution of Mechanical Engineers and the SAE. He was awarded the Arch T. Colwell Award in 1966 by the SAE. Mr. and Mrs. McDonald reside in North Hollywood, California.

STATEMENT OF WILLIS M. HAWKINS, CHAIRMAN, AEROSPACE SAFETY ADVISORY PANEL, ACCOMPANIED BY NORMAN PARMET, GEN. LEE DAVIS, HERBERT GRIER, JOHN McDONALD, MEMBERS OF THE AEROSPACE SAFETY ADVISORY PANEL

Mr. HAWKINS. I brought a few members with me from the panel itself, although it is not the complete panel.

You see on my left Norm Parmet, ex-vice president of Engineering for TWA, now retired. Next to him is Gen. Lee Davis, formerly of the Air Force and the Draper Laboratories. On my right is Herb Grier, who is retired from EG&G, Inc. and was the previous chairman of the Aerospace Safety Advisory Panel. On the right is John McDonald, one of our new members that I mentioned in my testimony, and is retired from Flying Tigers. He brings airline experience, along with Norm Parmet, to our panel.

Then we have Gil Roth behind us, who keeps track of us for NASA, and is our NASA staff director.

Mr. Chairman, today I would like to say that we have participated in all of the NASA activities for the last year, 1982, in much the same pattern as we have done in the past. We have major factfinding sessions with the whole group interspersed with specialized visits by panel members to individual centers or individual problem areas. We have had four major factfinding sessions during the year and have met with NASA an additional 36 times, one way or another, with members of our panel.

We think that this has been entirely adequate to cover the shuttle program and I would like to report that NASA has continued to be fully cooperative with the panel. We sometimes do not bring good news to NASA but we have never found any problem with exploring the adequacy of the hardware and their accompanying safety practices, and they have always made available the people and data necessary for us to do this task well.

During 1982, the Space Transportation System began its transition from an R&D type program to one that was officially operational. Now as I reported to this subcommittee last year, we have attempted to change the membership of the panel in order to properly assess these operational functions. We have brought in these two men that I introduced to you today, John McDonald and Norm Parmet, from the airline industry, and they have been serving with us for the entire year.

In addition to them, we brought in Mr. Gerald Elverum of the TRW Co., who is an expert in the business of liquid propulsion systems, and we have retained his predecessor, Dr. Sy Himmel, who is formerly of NASA Lewis Research Center, because of the critical

elements of safety associated with shuttle propulsion systems. Dr. Himmel is completely familiar with the shuttle engines, and we are retaining him until we think those engines have gotten into their operational status.

In addition, we have asked Mr. Robert Rothi to join us as a consultant until we have a membership available that opens up because of people who retire from the panel. He is from the Douglas Aircraft Co. and brings to us real experience in complex aircraft power and control systems, landing gear systems, and brings to us the experience that has come from commercial transports that have been advancing almost as fast as any kind of a military transport or space system.

Last year the entire panel emphasized, and we want to reemphasize, that the performance as demonstrated by flights 3 through 5 is really a miracle of accomplishment, and NASA should be complimented on achieving their goals so close to the schedule.

The reason I want to say this and emphasize this is, of course, that anything that a safety panel might say sounds negative, and so we proceed to tell them where we think things are in trouble, but they have done a remarkable piece of work.

We have made a substantially more detailed report to Jim Beggs, Hans Mark, Stan Weiss—the new Chief Engineer—and Mike Weeks, the Deputy Associate Administrator for the Office of Space Flight. General Abrahamson was not there for this particular presentation but he has been with us steadily all during the year.

The findings and recommendations, and the plans of the Aerospace Safety Advisory Panel for 1983, are covered thoroughly in that report to the administrator, and I propose that the whole report be entered into the record as well as these statements of mine.

What I would like to do today is to cover most of our findings and recommendations and then let you ask questions of our panel members. We think, as the first finding, that the flights to date on the Space Transportation System have demonstrated only the nominal performance of the shuttle. All of the systems have been working and the flights have been successful.

The transition to operations has officially been made but the fact of the matter is that the flight tests to date have not confirmed the far corners of performance of the shuttle and they urged NASA to put instrumentation in their operational flights to be sure that in their plans for the future they cover those corners of the shuttle performance envelope. This is not the type of program that you would normally go through in certifying an aircraft, wherein you have to reach all these corners before it is certified. It is a transition problem for the shuttle.

Our second finding is that the flight envelope includes demonstration of the structural loads against that which has been estimated as well as the capability of the structure. In your discussion with the Air Force you pointed out the fact that changes are going to have to be made to the shuttle in order to improve the performance to fulfill the complete Air Force mission and, of course, some commercial missions in the future.

When you are trying to lighten the structure and are trying to change and improve the performance of the orbiter when you have

US PARTICIPATION IN GIOTTO MISSION

Experiment	US Co-Investigator
Camera	W.A. Delamere, Ball Aerospace Systems Division, Boulder W.F. Huebner, Los Alamos Scientific Laboratory F.L. Whipple, Harvard College Observatory, Cambridge
Neutral Mass Spectrometer	J.H. Hoffman, R.R. Hodges } The University of Texas at Dallas
Ion Mass Spectrometer	D.T. Young, Los Alamos Scientific Laboratory M. Neugebauer, R. Goldstein, B.E. Goldstein, W.T. Huntress } Jet Propulsion Laboratory E.G. Shelley, R.D. Sharp, R.G. Johnson } Lockheed Palo Alto Research Laboratory A.L. Lazarus, H. Bridge } Massachusets Institute of Technology
Dust Mass Spectrometer	B.C. Clark, Martin Marietta Aerospace, Denver J.F. Friichtenicht, TRW Inc., Redondo Beach Z. Sekanina, Jet Propulsion Laboratory H.A. Zook, Lyndon B. Johnson Space Center, Houston

US PARTICIPATION IN GIOTTO MISSION

Experiment	US Co-Investigator
Dust Impact Detector System	W.M. Alexander, Institute for Environmental Studies, Baylor University, Waco, Texas M.S. Hanner, Z. Sekanina } Jet Propulsion Laboratory
Fast Ion Sensor/ Implanted Ion Sensor	J.D. Winningham, Southwest Research Institute W. Feldman, Los Alamos Scientific Laboratories
Electron Analyser/ Positive Ion Cluster Analyser	K.A. Anderson, C.W. Carlson, R.P. Lin, A. Wekhof } Space Sciences Laboratory, University of California, Berkeley D.A. Mendis — Dept. of Applied Physics, University of California, La Jolla
Magnetometer	M.H. Acuna, L.F. Burlaga, N.F. Ness } Laboratory for Extraterrestrial Physics, GSFC
Optical Probe	J.L. Weinberg, F. Giovane, D.W. Schuerman } Space Astronomy Laboratory, University of Florida, Gainesville
Giotto Radio Science	P.B. Esposito, JPL
Halley Environment Working Group	R. Newburn, Z. Sekanina, M.S. Hanner, N. Divine, D. Yeomans } Jet Propulsion Laboratory

not explored all of the flight envelope corners, it is a tricky course. We have asked NASA to approach its performance improvement changes with extreme caution so that they do not trip en route to getting additional performance. NASA has been completely cooperative with us in every suggestion we have made, and I think that they will proceed with caution.

Our third finding noted there are major differences between an operational shuttle system, a transportation system, and R&D system, and that is why we have brought some airline people to the panel. The fact of the matter is, this is far from being an airline and it will never be an airline in the normal sense of the matter. However, there are many systems that the airlines use that could help the shuttle program to prove its operational economy, increase flight frequency, reduce turnaround times, and assure that all of those things are done safely. One cannot cut corners in order to do these things, therefore the maintenance procedures and everything necessary, logistically speaking, has to be done properly to assure safety.

We suggest that this probably requires a major operational organization within NASA, so that they are not diverted by R&D interests including performance improvements. We have made this suggestion to NASA before, and they are certainly considering it, and have taken some steps in this direction.

In addition to this and along with this operational organization, we suggest that that organization should have control of the shuttle configuration. They should decide which of these improvements should be inserted and when. We also suggest that a lot tighter control system be put on the whole NASA organization to maintain control of changes, to do them in an orderly fashion and to know the real configuration of the shuttle.

Our fourth finding is that along with the creation of this operational organization, that NASA have a sustaining engineering activity that answers to the head of the operational organization. That this sustaining engineering activity will not be an R&D organization. It will be one that works out such things as the logistics requirements, flight procedures, testing standards, quality assurance standards, all of which have to be met for these quick turnarounds. Further, they will not be subject to any of the pressures of R&D and performance in doing their engineering task.

The fifth finding is that we think that the schedule pressures that have been working on NASA have had a subtle impact on the rigor of the certification of the hardware and software. I think the problems NASA is having with the main engines right now are an illustration of that, and that the rigor of certification must not be lost when we make changes in order to improve the system performance.

The panel has just had a briefing by NASA's Chief Engineer's organization, and they are trying to work out this independent certifying function which we recommended.

Our sixth finding is that with the accomplishment of the many successful reentries including orbiter control through the transonic region, the immaculately done approach and landings, now is about the time for NASA to try the system that is built into the shuttle, namely the automatic landing system. The panel has listened to

the astronauts who have flown and those who are going to fly, and we agree with them that we should probably wait until they get the heads-up display system into operation. Additionally it would be a good idea if the man who first tried it was one who has already landed the shuttle. NASA is trying to schedule this right now.

Our seventh finding is probably as critical as any, and is being demonstrated right now. We think that the turbo-machinery in the shuttle's main engine has probably reached further into the state-of-the-art of any of the mechanisms in the shuttle. So far the main engines have not achieved the performance before failure that would really be called operational.

The panel recognize the fact that some of the problems NASA has with this turbo-machinery could only be solved by some redesign. We have suggested to NASA that they go into a rather large but selective spares program to assure there is enough turbo-machinery, to replace the parts they have now and maintain their schedule while redesigning the rotating machinery in the main engines.

Our eighth and last finding is that the landing gear and the wheels and tires and brakes appear to be the most seriously overloaded elements in the shuttle system. The panel believes that actions could be taken to give more margin to this landing gear system. We have suggested that NASA take a hard look at the landing gear and perhaps make some changes in it because it looks like it will be reasonably simple to make those changes.

I have told you that the total report has been delivered to NASA and it should form part of this testimony because it contains all of the details. The report includes an official list of our current membership and the helpful staff and consultants. It also contains the Aerospace Safety Advisory Panel's plans for 1983. We are going to spend substantially more time in the future on the shuttle payloads including the spacelab that you have just talked to ESA about, and the upper stages, particularly the IUS and the Centaur.

That just about covers everything that the panel had to say and the main findings that we had in our report. I am sure these panel members would be very happy to answer questions. They may want to offer some additional suggestions to my summary if I have missed anything.

[The prepared statement of Mr. Hawkins follows:]

STATEMENT OF

WILLIS M. HAWKINS
Chairman, Aerospace Safety Advisory Panel

before the

SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

Mr. Chairman and Members of the Subcommittee:

The Aerospace Safety Advisory Panel (ASAP) has participated in NASA activities in much the same pattern during 1982 as it has done in the past. We gathered as a major fact-finding group approximately four times but these group meetings were supplemented by specialized visits of either an individual member or several members of the Panel an additional 36 times. We believe that this has been adequate to cover the program of Shuttle flights STS-3 through -5, and I would like to report that NASA has been fully cooperative, welcoming our requests for information and providing the people and data necessary to accomplish a reasonable review of the adequacy of the hardware and accompanying safety practices.

During 1982 the Space Transportation System program began its transition from an R&D-type program to one that was officially operational. As I reported to you last year, we have attempted to change the membership of the Panel in order to properly assess not only the R&D progress and the confirmation of flight characteristics and performance of the systems, but also the planning and operational procedures in order to see that none of these operations violate the capabilities or margins of the hardware. John McDonald and Norm Parmet joined the Panel last year and were fully operational in 1982. They bring their experience as managing engineers for airlines to the operational evaluation of the Space Transportation System. In addition to McDonald and Parmet, during 1982 we added Gerald Elverum from the TRW Company because of his expertise in liquid propellant systems. Mr. Elverum replaced Dr. Seymour Himmel who completed his Panel term. Since Dr. Himmel was fully familiar with the main propulsion systems in the Shuttle, and since it is one of the critical elements to the safety of the Shuttle, we have retained Dr. Himmel as a consultant to help us in the transition and to advise us until we are satisfied that the propulsion units are approaching operational status. We also added Mr. Robert Rothi as a consultant until a membership position on the Panel opens up when other members reach the end of their term. Mr. Rothi is from the Douglas Aircraft Company and brings to us many years of experience in complex aircraft power, control, and landing gear systems - all of which must function reliably to achieve operational reliability in the Space Transportation System.

As we noted last year, the entire Panel wishes to emphasize that the performance as demonstrated in flights 3 through 5 is a miracle of accomplishment, and NASA should be complimented on achieving their goals so close to schedule. We have made a substantially more detailed 1982 report to the NASA Administrator James Beggs and members of his staff, including Deputy Administrator Dr. Hans Mark, Dr. Stan Weiss, the new Chief Engineer of NASA, and Mr. Mike Weeks, Deputy Associate Administrator for the Office of Space Flight. The findings, recommended actions, and the plans of the Aerospace Safety Advisory Panel for 1983 were covered thoroughly in our presentation to the Administrator. For this hearing I propose to cover, in summary form, our current concerns with operational safety in NASA and the suggestions we have made which might resolve these concerns.

1. The flights to date on the Space Transportation System have demonstrated the nominal performance of all of the systems within the Shuttle and the ground support functions which must be provided to make the flight a success. Although the transition to "operation" has officially been made, the necessary flight information to fully confirm that the Shuttle is capable of flying up to its design limits is far from complete. We have urged NASA to plan the instrumentation and the flight instructions for subsequent operational flights to fill in needed flight data to demonstrate the total performance envelope as soon as it is possible.

2. We noted to NASA that this flight envelope means the demonstration - among other things - of the structural loads that have been estimated and the capability of the structure and the flight systems to reach the corners of the envelope demonstrating that the structure and flight systems are, indeed, capable of full expected performance. We have noted that parallel efforts are in progress to improve the payload performance of the Shuttle system implying, if not demanding, reduction in the dead weight of both systems and structures, with a probable reduction in the margins of safety of those systems. We urged NASA to approach such improvement changes with extreme caution until they have demonstrated in flight the capabilities of the current Shuttle configuration.

3. The ASAP recognizes that there are major differences between an operational Shuttle system and an airline, but we also note that the operational economy, the frequency with which the Shuttle may be flown, and the systems for turning around the Shuttle between landing and next launch, all could benefit from airline logistics and maintenance procedures which have been developed to minimize time on the ground without jeopardizing the safety of flight. We believe that the operational procedures, the approach to inspection, the outlining of required tests, all are sufficiently different in an operational system from the procedures used in an R&D program that a major operations organization is justified within NASA Headquarters to add emphasis to the logistics planning and scheduling of the operational flights. We think this organization should concentrate on procedures for safe turn-around, safety

monitoring of cost-reduction programs, the control of the Shuttle configuration, and the changes that are being proposed for performance and operational improvement. We have suggested that this operational organization should control what R&D is to be done via a subcontract relationship with the R&D community (Centers) inside NASA.

4. Along with the creation of an operational organization the ASAP suggests that a sustaining engineering activity must be created to serve such an operations organization. This engineering activity would provide the information and judgment necessary to develop operational turn-around and flight procedures, testing standards, maintenance and logistics requirements, and quality assurance activities. This important engineering function, essential for sustained safe operations, should be supported by operational funds and its engineering activities should not be confused with the engineering required for R&D and performance improvements. Specifically, its funding should not be subject to reduction when inevitable R&D and design change budget pressures appear.

5. The ASAP believes that schedule pressures may be having an impact on the rigor of the certification being applied to Shuttle changes. A certification process necessary for an R&D program is inevitably more flexible than one designed for safe operation of an operational vehicle. The ASAP further suggests that the policy and standards for such certification should be done by an independent organization, preferably at NASA Headquarters. We have recommended that this be a function of the NASA Chief Engineer's organization. With such an independent certifying function, not only will the design function be provided with consistent standards, but it will also be possible to set up the standards for certified safe operations processes, inspection requirements, and the frequency and content of repetitive test programs.

6. The accomplishment of successful re-entry, control through the transonic regions, and the approach and landing has been done immaculately by the thoroughly trained and capable crews. The Panel urges NASA now to demonstrate, as soon as feasible, the autolanding capability that is built into the Orbiter. We recognize that this demonstration must be done properly and we recognize that it involves even more responsibility for the flight crew. Therefore, we concur with the expressed desires of the astronaut pilots that the heads-up display be available before autoland is attempted, and that the commander in charge of such a demonstration flight be a member of the astronaut corps that has already experienced a complete Shuttle operation.

7. The turbo machinery of the Shuttle's main engine probably represents the most ambitious approach to the boundary of the state of the art of any system in the Shuttle. It is not surprising, therefore, that the high pressure oxygen and hydrogen pumps have not, as yet, achieved the demonstration of a design lifetime before failure can be expected. It is the Panel's opinion that a major redesign will have to take place before these pumps achieve truly

operational performance. This means that a parallel program will be required involving substantially more than nominal spares for current machinery while the redesign and testing takes place to fully qualify the truly operational turbo pumps.

8. It would appear that the landing gear, wheels, tires, and brakes are probably the most seriously overloaded elements of the Shuttle system. The Panel believes that there are redesign approaches which could restore nominal margins of safety to elements of the landing gear system and that these should be pursued. One such suggestion is that the nose gear might be lengthened in order to reduce the nose-down attitude of the Shuttle on the ground, thereby reducing the roll-out loads on the main wheels, tires and axles.

The total report which we have delivered to NASA, and forms a part of this testimony, contains more detail on why the Panel has reached the conclusions I have just summarized. The report includes an official list of our current membership, the extremely helpful staff, and the consultants which we are using in our day-to-day activities. Also included are the plans for the Aerospace Safety Advisory Panel for 1983. Apart from the Space Transportation System evaluation which I have summarized, the ASAP spent substantial time during 1982 evaluating NASA's approach to flight safety for test and administrative flight operations at its various centers. NASA has responded well to our recommendations, and we will follow the new procedures developed and the revitalized safety organizations to be certain that enough has been done to maximize flight safety. No major conclusions or recommendations have been developed for the safety impact of payloads to be carried in the Shuttle. The most critical of these payloads, we believe, are those which contain propulsion or pyrotechnic units - the most notable of which is the proposed large-tank Centaur. Although the Panel has been briefed on the details of this installation, we fully intend, during 1983, to delve substantially deeper. A similar comment should be made concerning the proposed filament-wound lightweight solid propellant motors and the soon-to-be-flown lightweight external oxygen-hydrogen tank.

We have with us today a number of members of the ASAP and, with your permission, I would like to ask if any of them have additional comments they would like to make. We are, of course, all available to answer questions which you may have.

Mr. VOLKMER. Well, thank you very much, Mr. Hawkins. We will proceed with the questioning.

Does the gentleman from Florida have any questions?

Mr. MACKAY. Mr. Chairman, I want to be sure I understand what Mr. Hawkins is saying.

You are saying that you have made these recommendations to NASA and that they are under consideration. What built-in mechanism is there to assure you and us that something is going to come of them, other than you coming here and telling us it is?

Mr. HAWKINS. In our working procedures with NASA and in our investigations, we follow up these particular suggestions ourselves and NASA responds to the Panel completely. They do not always accept our suggestions, and may say, "No, we are not going to do this." So when we have gotten a certain amount of fussing from some of the NASA folks and they do not do something, we will mention it again next year and put on a little more pressure.

However, the fact of the matter is that their responses have been absolutely complete from a standpoint of what NASA is going to do from a policy standpoint on all of the suggestions that we make.

Mr. MACKAY. I am particularly interested in the structural changes you recommended within NASA, as it becomes less of a first-time program and more of a continued one. You suggested that they develop a different type operation that is analogous in some ways to what an airline has.

Mr. HAWKINS. Well, you must recognize that NASA as an agency has never had what you would call a routine operational responsibility. It is predominantly an R&D organization. All of the panel members have been involved in major development programs, and generally speaking you cannot get the engineers to quit playing with the thing until the airline takes it over. What we are trying to suggest is that they introduce what is, in effect, an operating organization, so that they will have a real barrier against making changes that are made because it is nice to make them. We think NASA will have to do that before they get this shuttle system down to the economy, quick turnaround and reliability that I think it has. That is our suggestion to do it. Now NASA may want to do it differently but the fact is, I think they have to step up to this approach.

Mr. MACKAY. Do your suggestions include timeframes within which this should be done?

Mr. HAWKINS. No, we have never put timeframes on it. However we have made that suggestion on some other detailed suggestions, for example "Why don't you aim for flight such and such" but not for an organizational arrangement.

As a matter of fact, General Abrahamson's assignment and the character of his assignment last year was in a major way in response to the suggestion we had made previously.

Mr. MACKAY. Your suggestion No. 5 appears to be one that is almost like a warning, that you have a conflict built in. You are saying the schedule pressures may be having an impact on the rigor of the certification. Am I interpreting that properly, that you——

Mr. HAWKINS. We have suggested they hold up a little bit on making performance changes to be sure that those performance

changes that are made are followed with the same rigor, the same quality assurance procedures, the same previous testing used when NASA made the part originally. We have seen areas where this has not been done and it has bitten them. So, we are saying, "Let's not let the pressures of flight get ahead of us here."

Mr. MACKAY. Then, finally, your suggestion for redesign, you are essentially saying that in the process of the first flights and the learning that is occurring there, it is apparent to you that there are areas where there needs to be redesign. I am just asking this question as a newcomer on the block: Is that built into the program now?

Mr. HAWKINS. No. Our suggestion concerning the landing gear, particularly, I think is probably the one that you have as an example.

Mr. MACKAY. Yes.

Mr. HAWKINS. As for the turbo machinery redesign, I believe it is fundamentally in the program or it is beginning. The landing gear redesign is partially in, although our suggestion may not be the best. Maybe there is a better suggestion, but I am sure that they are aware of it and they are working on it very hard. They may not do it just the way we suggested, but that way may be better.

Mr. MACKAY. Is the landing gear—wheels, tires, and brakes—overloaded because of underdesign originally or because of changes which added to the load after that part was originally designed?

Mr. HAWKINS. I think the answer to that is underdesign originally, in order to keep the weight down as far as possible. Although the landing gear work each time, it is working so close to the margin that I believe when they get additional payload on it to meet Air Force needs or the extra weight they are going to have to carry some day, they may use up the margin. We suggest they get at it now before they unduly stress it.

Mr. MACKAY. Mr. Chairman, I would certainly think—although it is somewhat presumptious in my brief service on this committee—that it would be well for the committee to ask for a written follow-up on these suggestions. I think they are excellent suggestions. I am glad to know this program is built into NASA, and it seems to me this subcommittee probably has the responsibility to follow up to see or evaluate for ourselves what NASA does.

Mr. HAWKINS. I suggest that we just ask the staff to send you a copy of NASA's response to us.

Mr. MACKAY. That may be happening already. I am not aware of it.

Mr. VOLKMER. I would appreciate, if you could, say last year's and this year's recommendations and NASA's response to those, if we could have those so we could review them.

Mr. MACKAY. Thank you, Mr. Chairman.

Mr. VOLKMER. All right, Mr. MacKay.

I now recognize the gentleman from California.

Mr. LOWERY. Thank you, Mr. Chairman.

Could you comment from a safety standpoint on the engine leaks on the current shuttle and some of your suggestions for improvement? You talked about having a larger spares program, and you likewise talked about some reengineering.

Mr. HAWKINS. Well, any R&D program has a problem before it really tests something, that is, have you got it right in the first place? Therefore, there is a reluctance to buy a lot of hardware if they are going to have to throw part of it away because it does not work. NASA has had the difficulty of trying to plan how many spares they are going to need concurrent with getting the R&D done.

I think the engine, because it has reached as far into the state of the art as it has, is the one that was most likely to trouble them, and it did. I think that the main engine turbo machinery is probably as difficult a problem owing to the hardware dynamics, the aerophysics of the flow through it, the materials used, and the temperatures that it has to put up with. I think it is sort of logical that they find themselves with this problem. I think they went operational or started to go operational before they had actually stressed the engines to its full limits, and——

Mr. LOWERY. If I might ask, why did the problem not show up earlier? Because it was not sufficiently stressed? Why did it not show up in the earlier flights?

Mr. HAWKINS. No, I think it is a matter of time. I think these things, this turbo machinery will work. It is a matter of how much time you get on the machine before you start flying it.

Mr. LOWERY. Is it wear, or——

Mr. HAWKINS. It is wear, mostly, and so the engine components do not last as long from a lifetime standpoint as they were supposed to. Therefore, you have to have more spares.

Now we are suggesting that one could get elements to last the full lifetime that was estimated——

Mr. LOWERY. Which is what?

Mr. HAWKINS [continuing]. And it is probably a good idea to go back and redesign it so that you will get that lifetime.

Mr. LOWERY. What was to be the lifetime?

Mr. HAWKINS. Fifty-five missions. I cannot remember the seconds it was supposed to run, but 55 missions, and I do not think that this turbo machinery should be used for more than 20 starts at the moment. It will be pretty close to its limit, so it is going to have to have extra spares.

Mr. LOWERY. That is what is responsible for the leaks?

Mr. HAWKINS. No; the leak problems have come from changes and repairs made to the engines. You can see the reasoning behind putting each one of the changes in, but the changes were made outside of the normal line of production, did not really get the full attention of QA nor the backup testing that went into the original parts. It turned out that the process that was used caused leaks. The material was damaged.

Mr. LOWERY. You tinker with something over here, and it has a——

Mr. HAWKINS. You are tinkering with something that was working, and you probably shouldn't have, but in each case you can see the intent of the tinkering, and the intent was right, to improve it, but it just didn't have the rigor of certification in it prior to making the change. That is why we had this finding.

Mr. LOWERY. Other than the shuttle, what else are you looking at?

Mr. HAWKINS. Well, we spend a lot of time on aircraft flight safety at NASA covering both the administrative airplanes, and the R&D experimental airplanes they fly. General Davis has been our specialist in this area. We have made quite a number of flight safety suggestions to NASA. You will find them in the panel's annual report including what NASA should do with their organization in order to coordinate the safety findings, safety experiences, from their various NASA centers.

We made a major effort last year, and we heard just this morning a response to that effort. It looks like they are doing most everything organizationally that they should. It is basically being centralized under the new chief engineer, Dr. Weiss, and I think they are responding very well to that.

We have limited our activities, as I think was the intent of Congress, to flight safety at NASA rather than handling the problems of industrial safety. To do this you probably should get people of different talents if you thought there was a real problem. I think they handle that pretty well in their own organization. For now, ours is primarily flight safety.

Mr. LOWERY. Mr. Hawkins and your panel, thank you very much.

Thank you, Mr. Chairman.

Mr. VOLKMER. Does the gentleman from Florida, Mr. Nelson, have any questions?

Mr. NELSON. Thank you, Mr. Chairman.

If this question was asked, Mr. Chairman, please just let me know. I apologize for being late. I have been testifying before the Rules Committee.

Have you all, from what you did in 1982, been able to give us your professional opinions as to whether or not we ought to be concerned as to the structural integrity of the engine operations as a result of the three leaks that have just come to our attention over the past several weeks?

Mr. HAWKINS. I think if you were very intimately aware of all of the details of the problems they have had, you would recognize the fact that they are being supremely cautious about this. You could be fairly logical, you would have a lot of argument on your side if you had said, "Oh, those are not important leaks; go ahead and fly," and there were some who said that. However, the fact is that NASA is approaching this very, very cautiously. These leaks were pretty minuscule, believe me, compared to the amount of hydrogen they were handling. I think they did it just right, and I see no fundamental problems demonstrated by these leaks.

I think there is one problem that they have already recovered from. These leaks were first uncovered with inadequate instrumentation. I think they have worked out a completely new acceptance process for checking out these engines when NASA receives them to be sure that no significant leaks do appear. That process has been completely changed and it is much better now than it was. I believe it is entirely adequate the way it is.

Mr. NELSON. Yesterday in General Abrahamson's testimony to us, he said that one of the changes that they will make as a result of the discovery of these leaks is that for some period of time in the

future—and perhaps you can tell me—that they will use the engines at 104 percent instead of going to the 109 percent.

Do you all as a panel of experts see any impairment or diminution of the program by NASA adopting this policy of going with 104 percent engines?

Mr. HAWKINS. No, I do not think so. I think it is a cautious approach, again. They did not need the 109 percent until they get to the major downstream payloads, and particularly those that are launched from Vandenberg. If I remember the performance requirements properly they are probably Air Force payloads.

Mr. HAWKINS. I think NASA would have preferred to actually use that higher power rating at a time when they did not really need it. I think what they will probably do is have fewer of those flights before the Air Force needs the 109 percent at Vandenberg than they had originally planned, and I think that is the proper way to do it. You should probably get a lot more information from ground testing.

It may be that one of these leaks is a result of the vibratory loads at 109 percent, because the last leak that has been found, were in those engines operated at 109 percent on the test stands. Therefore, I think this approach is all right and it will not hurt the performance as far as the Air Force is concerned.

Mr. NELSON. As far as you know, we are not missing out on any commercial payloads as the result of being at 104 instead of 109 percent?

Mr. HAWKINS. No.

Mr. NELSON. Did any of you all, in your examinations in 1982, did you ever get in detail into the solid rocket boosters?

Mr. HAWKINS. Yes, very thoroughly. We have been looking at those and will continue to look at them with a great deal of interest because they have now produced a lighter weight case which gets them some performance, and also they are working with a fiber-wound case that in the future will get even more performance. We have already had one meeting with fiber-wound case people, and we have already reviewed the lighter weight metal case. We think we see no unresolvable difficulties there.

Now we have also looked at it from a standpoint of whether or not these are inhibiting from a rate standpoint, and our major recommendation to NASA—which we made not last year but the year before, I think, and they are responding to this—that was to see to it that facilities are provided at Kennedy in order to get the assembly of the solid propellant elements out of the vehicle assembly building. I think that is all in the process and in the budget and they are responding to us in that regard.

That is a real worry we have, that the solid propellants have an awful lot of energy in them, and having to handle all those elements in the assembly building with the population that is in the building, we think is a hazard that could be avoided with the proper facilities.

Mr. NELSON. I appreciate that recommendation. I wonder why they never made that recommendation to begin with, and in fact a lot of that SRB activity was put in the vehicle assembly building along with all the other stacking of the transportation system?

Mr. HAWKINS. I suspect the problem was budget.

Mr. NELSON. Was there any safety aspect that came to our attention later that we did not know back then?

Mr. HAWKINS. I think not.

Mr. NELSON. Did you all inquire as to the ability to produce in excess of 24 sets of solid rocket boosters a year? I mean, theoretically when we get on up into 1988, 1989, 1990, we are supposed to be flying from 24 to 40 a year. Do we have that capability?

Mr. HAWKINS. Well, Mr. Nelson, one of the things that we have to do is inhibit ourselves a little bit to be certain that we are dealing with only those matters that are safety, and that is what we are here for.

Mr. NELSON. I see.

Mr. HAWKINS. When we see high-rate things being proposed, we look at them all, but I do not think it is part of our responsibility to suggest that they are doing it wrong unless there is a safety problem involved. We are not the economic monitors of what they do.

For instance, we may have overstepped our bounds a little bit on recommending some of these organization changes, but we feel that it has a safety impact. When you try to move a thing like this shuttle into a higher rate of flight, you want to be very sure that you have your procedures all worked out so that you are doing the checkouts that you should do when you turn it around, rather than skipping one that you maybe ought not to skip.

Therefore, when you come to the high rates, we will be looking at its safety impact but not whether they are doing it properly or planning it soon enough. There is another panel, I think, that is working on that. I think Congress has asked for that, but we do not do it.

Mr. NELSON. Was it your panel, by the way, that did the investigation after we had a couple of the workers killed just prior to the launch of STS-1?

Mr. HAWKINS. Yes, but——

Mr. NELSON. I appreciate your thorough examination.

Mr. HAWKINS. Well, we did an examination of the data that came from the investigation. We did not do the investigation. We are not constituted to do accident investigations.

Mr. NELSON. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you.

Do you have further questions?

Mr. MCKAY. I had one which occurred to me. Does the organic statute or provision which you established contemplate that you will make recommendations as to whether the limits of your authority are functional? In other words, are you inhibited in any way functionally?

Mr. HAWKINS. We do not think we are inhibited functionally at all. I think we draw our own limits. I mean, there are so many problems that an organization like NASA has that in order to keep ourselves focused on the safety aspects of it, we have to be self-limiting, if you will. No, we are not inhibited.

Mr. VOLKMER. OK. I have several questions.

How would you assess NASA's planning to provide the right balance between having safe reflights—in other words, when we get into the 24 a year, with the 3 operational shuttles and one being

repaired and getting ready to go up again, 4 total—and demonstrating economical shuttle operations?

Mr. HAWKINS. We think that—and we have made these comments to NASA—we think that they have done quite a lot of good planning. We are not quite sure they have the organizational structure to follow those plans, and that is the foundation of our recommendation that they set themselves up an operational organization that has only that responsibility. We made that recommendation, because the planning they have done is good but it has not permeated the whole organization yet as an operational plan.

Mr. VOLKMER. Are you aware of any unresolved safety issues concerning the space shuttle?

Mr. HAWKINS. Not that they are not working on.

Do you panel folks have any worries about this? I hope you will pipe up if you think that I have not covered it.

Mr. MCDONALD. No.

Mr. GRIER. We have been talking to them about bailout, crew safety, that sort of thing. It is a very, very difficult problem, and they are beginning to work on it but it is——

Mr. VOLKMER. In case they have to abort a mission?

Mr. GRIER. They have to abort, and how do you get out, and that sort of problem. They are responding properly. It is a question you could not expect them to just jump into because the answers are not clear. It is an area that is just kind of in limbo and needs to be pulled together, and they are starting on that.

Mr. VOLKMER. Have you done any studies, made any recommendations as to testing required for the orbiter thermal protection system between flights?

Mr. HAWKINS. Well, we went through that very, very thoroughly about 3 or 4 years ago when they were having difficulty with adhesion of the thermal protection system on the orbiter. We have made, you will find it in the major body of the report, a suggestion that the change that they are making on the next orbiter where they take some of the tile off and replace it with blankets, that they go back and review it to be certain that they have gone through all of the testing procedures that the tiles had to go through in order to prove their efficacy.

NASA has taken that wholeheartedly and has done some additional testing, but as far as we know we have no concerns about the thermal protection system and the way they are handling it.

Mr. VOLKMER. All right. Have you reviewed, say, the safety issues relating to development of a high-energy upper stage such as the Centaur?

Mr. HAWKINS. We have already had a review of the total program but we have not gotten into it in the detail that we intend to do in this next year. You will find that as a major item for panel activities in the year 1983. The panel will include all the other upper stages that have propulsion pyrotechnic elements.

Mr. VOLKMER. Would you like to comment on whether—getting back to the timetable of 24 flights and so many orbiters and getting them ready, tested, and so forth, reengineered, everything back on and getting them ready to go again—from a safety viewpoint, do you think it would be better to have additional orbiters, say another orbiter—instead of four, have five—to meet necessary turn-

around times than to reengineer the existing design to meet those times?

Mr. HAWKINS. We have made some rather specific comments to NASA on the subject of the fifth orbiter, because it has several elements to it. We thought we detected within NASA the desire to get a fifth orbiter in order to keep their supply lines open to the various people who worked on parts of the shuttle, and we made some very pointed remarks to NASA that this is not a substitute for a well-planned spares program. In other words, you should plan the spares first, order your spares, and then find out whether or not there are some suppliers that might be available or might be needed for spares that you would have to artificially keep open.

We think that the compromise that they have reached, whereby they are buying essentially spares elements, structural spares—which are the kinds of things you do not normally buy spares for but you would if you knew the production line was going down. Therefore, I think that what they have done with respect to ordering structural spares for a fifth orbiter probably makes sense, but it is not a substitute for a normal spares program which buys as many landing gears as you think you are going to need, or as many tires and wheels and turbo pumps and everything else. We have seen planning for that spares program but we have not seen the ordering thereof, yet. This is one of the other elements of getting an operational organization together that tries to see that its plans are fulfilled.

Mr. VOLKMER. All right. Have you studied the concept of the maneuvering operations outside the shuttle for, let's say, the solar maximum mission retrieval?

Mr. HAWKINS. We have looked at their plans for EVA in substantial detail and have made no detailed recommendations. We felt that the concept of the EVA ought to be revisited because of the pressure in the suit that they have now, the pressure within the cabin of the shuttle, and the time it takes to suit up and get out into space is inordinately long. They ought to go back and take a look at their concepts to see if they can be satisfied with the relative immobility of a higher pressure suit which allows suiting up and getting out and back in again without this long time span. That has been our contribution from a recommendations standpoint so far.

Mr. VOLKMER. Have you reviewed the problem that the satellite is actually moving at the time that they attempt to retrieve?

Mr. HAWKINS. We have not looked at the detailed dynamics of that but on our meager information I do not think there is any real known safety problem involved.

Mr. VOLKMER. No safety problem?

Mr. HAWKINS. No.

Mr. VOLKMER. I have no further questions.

Mr. Nelson, I believe, has a question.

Mr. NELSON. Yes, sir. Thank you, Mr. Chairman.

I am curious, have you all looked at the safety aspects as affected by morale of employees? For example, suppose a recompetition were brought about and you had a sudden shift in the awarding of the contract to a new contractor, and there was a sudden shift of employees from one company to another. Have you all ever looked

at the morale factor as it affects safety during such a transition time?

Mr. HAWKINS. I do not think we have addressed that as a panel subject. There are a number of us on the panel who have had experiences in supporting space activities of one sort or another, and generally speaking, the transition has been done many, many times and it has been done fairly smoothly. It is a mechanism by which one can get more economical and more efficient operations.

Therefore, I think as a panel we ought not to comment on it, but I do not think we have as individuals, any negative comments on the subject. I think that it can be handled.

Do you folks want to say anything about that?

Mr. GRIER. I would be more concerned by a 7-day-week, 3-shift operation, their effect on morale, than I would be by the change of contractor. The aerospace industry is a queer animal. People shift from contractor to contractor as the contracts are awarded, and that is not a real problem, but people do get tired. They get complacent and they get kind of stupid.

Mr. NELSON. How about the potential loss of job affecting the employee who is working on a particular activity, with regard to safety?

Mr. HAWKINS. Well, generally those people do not lose their jobs. They just work for somebody else.

Mr. NELSON. Well, you draw on a vast array of experience and expertise. In your experience, perhaps it is not a fair question because you all as a panel have not looked at it. If you have anything to contribute, I would be appreciative.

Mr. PARMET. One thing, if you generally have good management capabilities that have been established and good procedures, then the transition becomes relatively easy because the consistency of new management adapting to the procedures of the old is step one. If you continue them on and improve them, then I think you do a good job of transition. You cannot overcome individual morale problems. There is just no way.

Mr. HAWKINS. I think the overload of the people due to schedule is the biggest hazard from a morale standpoint.

Mr. NELSON. Do you see anything in the schedule as it is projected that would indicate that overload?

Mr. HAWKINS. Not as it is projected, I don't think so. I think they have projected it fairly well. I think we are over that hump. They had some terrible burdens down at the Cape in the early days, and we were concerned then but I think it has gotten over that hump.

Mr. VOLKMER. I have one additional question, to get back to the engines. As I understand the procedure that will be followed is that the corrections on the leakage of the hydrogen—the one little pipe that has a sleeve—it is to remove the sleeve, put the other pieces in, and then test No. 14 down at NSTL on a firing, place 12, 15, and 17 in the orbiter but not do any tests on those or even a preflight test. Does that give you any concern?

Mr. HAWKINS. You understand that the change they will make to those engines will be to put that part back on the engine just the way it was for the first orbiter?

Mr. VOLKMER. Oh, yes, I understand that, but you still have welding. You are still going to have weldings done.

Mr. HAWKINS. Yes; but they have a test procedure which will find out whether they did it properly and it leaked, which is the same procedure that found the crack in the first place.

Mr. VOLKMER. Right. Therefore, you have no reservations about that?

Mr. HAWKINS. No, no.

Mr. VOLKMER. I just wanted to make sure.

I thank you very much. We appreciate your being here and your testimony today.

The subcommittee will adjourn until tomorrow at 2 o'clock in this room.

[Whereupon, at 3:45 p.m., the subcommittee recessed, to reconvene at 2 p.m., on Thursday, March 3, 1983, in room 2325, Rayburn House Office Building]

1984 NASA AUTHORIZATION

THURSDAY, MARCH 3, 1983

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND TECHNOLOGY,
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS,
Washington, D.C.

The subcommittee met, pursuant to call, at 2 p.m., in room 2325, Rayburn House Office Building, Hon. Harold L. Volkmer (chairman of the subcommittee) presiding.

Present: Messrs. Volkmer, Nelson, Brown, Bateman, Lujan, Chandler, and Walker.

Mr. VOLKMER. The subcommittee will come to order.

Today, the Subcommittee on Space Science and Applications will continue hearings on NASA's fiscal year 1984 budget request by receiving testimony from officials of organizations outside NASA. These organizations represent not only scientists and engineers closely associated with the aerospace community, but also a cross section of the public that is concerned and interested in our national space goals.

We therefore welcome our witnesses today and look forward to their various viewpoints and perspectives of the Nation's civil space program.

Our first witness is Dr. Mark Chartrand, executive director, National Space Institute. He will be followed by Dr. Alan Lovelace, vice president for public policy, American Institute of Aeronautics and Astronautics. Dr. Lovelace is accompanied by Dr. Stan Rosen, chairman, Space Systems Technical Committee. Our final witnesses today are Mr. John Robinson, chairman of the Aerospace Division of the American Society of Mechanical Engineers, and Mr. Phillip Legendre, also of ASME.

Dr. Chartrand, you have a prepared statement. That will be made a part of the record.

Before we proceed, I would first like to mention that, as I understand, there has been a request that still photographs be permitted today. Without objection this will be allowed provided they are taken with minimum delay at the start of each organization's testimony.

If you wish to summarize or review your whole statement; you may proceed however you so desire, Dr. Chartrand. I understand you have a plane to catch.

[A biographical sketch of Mr. Chartrand follows:]

DR. MARK R. CHARTRAND

Dr. Chartrand is currently Executive Director of the National Space Institute, a not-for-profit organization founded in 1974 by Wernher von Braun and others to

foster a strong United States Space program. NSI has 18,000 members nationwide, and its current President is Hugh Downs.

Dr. Chartrand holds a Bachelors and Doctorate in the field of astronomy from Case Western Reserve University in Cleveland. Before coming to NSI, he was with the Hayden Planetarium in New York City, where he served as its Chairman for the past seven years. While in New York City, he also was an Adjunct Associate Professor at the Lincoln Center Campus of Fordham University and a Member of the Faculty of the New School for Social Research, where he taught a course in space industrialization.

Dr. Chartrand has written and lecutred to public and professional audiences throughout the country and abroad. He is the co-author of a textbook, currently under contract for two other books, and has published articles in such journals as The Astronomical Journal, Science Digest, Science 80, and OMNI.

He is a member of the American Association for the Advancement of Science, the American Astronomical Society, Sigma XI, the New York Academy of Sciences, and a Fellow of the Explorers Club and the British Interplanetary Society, among others.

Born in Miami, Florida, he has been employed at the Science Museum of Miami, the Cleveland Museum of Natural History, and as a consultant to may companies, museums, and publishers. He has directed science trips abroad to view solar eclipses. He has appeared frequently on national and local radio and television programs, speaking on astronomy and space topics, and for a year and a half had his own science radio program in New York City.

Dr. Chartrand currently resides in Alexandria, Virginia.

STATEMENT OF MARK CHARTRAND, PH. D., EXECUTIVE DIRECTOR, NATIONAL SPACE INSTITUTE

Mr. CHARTRAND. Yes, thank you, Mr. Chairman, both for the schedule and the understanding. I would like to thank you for the opportunity to testify on behalf of the National Space Institute.

The National Space Institute is a public organization and most of its revenues are received from dues from members. These are not generally aerospace engineers or people involved in the field. They are generally American citizens who are interested in the subject. Every year we survey them. Here are just a few examples of the surveys. We ask them about their opinions on the space program.

I will skip the portions of my testimony which attempt to document that the demographics of our members show that they are, I think, a cross section of the interested American public. But I do want to say that I think that is so, and that there is a large number of Americans who are interested in the space program who are not members. The sociologists' studies show about 14 million people.

What we did was to ask our members, or present to them a number of statements, on different subjects about the space program. Some of these sound kind of Draconian, rather extreme. But they have been things that have been suggested in the past couple of years. Rather than give you the quantitative results let me give you some qualitative answers, which I hope will provide some guidance to the subcommittee when it considers the NASA budget and response of the American public to your actions.

We asked them whether they thought manned space flight was more cost effective, or unmanned space flight was more cost effective than manned. They are very slightly negative on that. We asked them whether NASA should concentrate on unmanned activities solely, and they were extremely negative. We asked whether NASA should be abolished, and they were very, very negative toward that. We asked whether they thought NASA should be the

operator of the space transportation system, and they were generally positive.

When they were asked whether NASA should be chartered to allow it to have operations specifically, they were extremely positive toward that. When we asked whether NASA should let private industry take over all space applications, R&D, they were quite negative. They were also negative when we asked whether NASA should leave pure science to other agencies. In other words, they believe NASA is doing what it should be doing.

We asked them something about cooperation with the Soviet Union. They were somewhat positive on that, and extremely positive that we should cooperate more with our allies around the world. They did perceive that foreign competition in the space program is going to be very important in this decade; and they did perceive that the current administration is not particularly supportive of the space program, at least as they see it.

We get a lot of comments from our members, by phone, by letter and also in the many speeches and interviews that my staff and I do every year. One of their concerns is the military space program as well as the civilian space program, and their relationship. We asked them whether DOD and NASA should cooperate more. They were pretty neutral on that. We asked whether they thought the shuttle was primarily a military tool, a statement bandied about by the Soviet Union and a number of people in this country. I think they correctly perceived that it is not. The shuttle is a truck and it does different kinds of jobs, civilian and military.

We asked whether we should begin to build laser battle stations in orbit, something that has received publicity this year. They were mildly positive. When we asked whether we should continue to develop an antisatellite weapon, most realized the Soviet Union has a crude weapon and they responded positively.

But the most positive reaction was on development of a space platform, or manned space station. They responded 9.2 on this. The Soviet Union launched the Cosmos 1443 yesterday afternoon, and I am sure this will add some important fire to the debate over space stations.

We also asked them what parts of the space program they were interested in. The highest they ranked were space stations, planetary exploration, and spinoff technology.

Now, in light of these answers, let me just give you a few comments on the NASA budget that I think reflect our members', and I think the general public's, opinion. The administration has raised the NASA budget this year. That puts it back about where it was a decade ago. In other words, if you are talking about cutting budgets, NASA got its cuts in the 1970's. It certainly doesn't need any more now. It actually needs much more increase. But I am not sure whether that is realistic.

OMB is trying to have it both ways. They constrain the testimony, of course, of, say, the witnesses that were on Tuesday afternoon. They say that we should not provide for the commercial flights except what is leftover capacity for the shuttle. On the other hand, they complain about the increasing costs because there are not enough flights. So you really can't have it both ways.

The agency certainly should put a proper emphasis on getting the shuttle operational. But there is a problem here. If you decide NASA is doing a good job in the things it originally set out to do, and you decide you want a good space transportation system, consider the two as separate goals, I think, to some extent, as part of one budget. Don't let the shuttle continue to steal, as it has over most of the decade, from the science and applications budgets.

The space science and applications budget is very heartening this year. The observatory, space telescope is extremely important; Galileo is extremely important. But there are concerns. Things like materials processing are concerns. I am happy to see some money in there for ion propulsion, but I do think we need more specifically earmarked funds in the NASA budget for a space station effort.

I am not saying we definitely need a space station. I am saying we definitely need to know whether we need a space station. We need to know now or very, very soon, and much faster I think than the NASA schedule now allows, whether we can use a space station for civilian and military purposes. I think the studies should be augmented and funded at the rate that will give us the answer at the nearest possible time.

There is also something else which is not really reflected in the NASA budget at all; that is, some of the historical preservation. Congress mandated NASA and the Air Force to provide for historical preservation sometime in the past. Yet it has expected those agencies to take the funds out of their existing funds. I don't think that is quite fair. We are in danger now of losing what I might call the equivalent of the pier from which Columbus sailed. I think something should be done about that in the near future.

Also, it is time to take another close look at NASA and see whether the NASA Act should be amended. We have Congressman Akaka's bill to establish a space commerce, the Commerce Department for Space Authorizations. We have Congressman Brown's bill on space policy—and this Nation really has no good space policy, at least not one the public has seen. We need those, and we also need to take a look at our international treaties to see if they preclude any international involvement.

But finally, let me just summarize what the NASA budget as it is really means. The $7.1 billion that has been requested is 0.84 percent of the Federal budget. At the height of the Apollo program the NASA budget was over 4 percent. The Government will spend 14 times the NASA budget merely on interest on the national debt this year, and the spending on space program nationally comes to about $66 a taxpayer, or if you take the entire NASA budget, it is about the amount the Americans spend on radios, televisions, and music equipment, equipment they wouldn't have without spinoff from the space program. I have documented some of these in the addition I have asked be included for the record.

At this point, Mr. Chairman, I would be willing to take your questions.

[The prepared statement of Mr. Chartrand follows:]

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STATEMENT OF

DR. MARK R. CHARTRAND
EXECUTIVE DIRECTOR
NATIONAL SPACE INSTITUTE

BEFORE THE
SUBCOMMITTEE ON SPACE SCIENCE AND APPLICATIONS
COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

3 MARCH 1983

(HOLD FOR RELEASE UNTIL PRESENTED BY WITNESS)

Statement of

Dr. Mark R. Chartrand
Executive Director
NATIONAL SPACE INSTITUTE

before the
Subcommittee on Space Science and Applications
Committee on Science and Technology
House of Representatives
3 March 1983

Mr. Chairman and Members of the Subcommittee:

Thank you for the opportunity to testify on the proposed 1983 NASA budget, on behalf of our members and the American public.

As you may know, the National Space Institute is the nation's oldest public interest organization connected with the space program, having been founded in 1974 by the late Dr. Wernher von Braun. It is my belief that our 12,000 members represent the segment of the American general public best informed about the nation's space program and its domestic and international effects. One of the most important objectives of NSI is to bring to responsible policy makers such as yourselves the opinions of the public concerning the space program. In this way we complement the professional and career-oriented testimony of our colleagues from the other societies that are here today.

In order to evaluate the feelings of the voting public on the subject of space, we survey our members each fall, asking them to rank their agreement or disagreement with a number of statements about the space program. Today I would like to present those results to you, and then to comment on the proposed NASA budget in the light of those opinions and of the many contacts we have with the general public.

Before I present the results, let me first characterize our members, in order to demonstrate that those results are indicative of a much broader public opinion. The average age of our members is 33.4, with an average family income between $20 and $30 thousand. They

are members of NSI not because of career but because of life-long interest. About 40% are in technical fields, about 28% in professional fields, about 20% in non-technical fields, and 12% are students. 58% of them have at least a bachelor's degree. 10% of our members surveyed responded, which provides good statistical confidence in the results.

The issues covered in the survey were posed as statements. The respondents were asked to rank their agreement with the statements on a scale such that complete disagreement is scored 1, a neutral position is 5, and complete agreement is 10.

Two other points are of interest before getting to the opinions themselves: first, when asked to characterize themselves on the political spectrum by indicating agreement to the statement "I would describe myself as politically conservative," the average response was 5.8; in other words, the respondents represent a balance of political beliefs. Second, when asked to rank themselves on the statement "I usually vote in national elections," the average response was 8.9. This high result is consonant with other studies conducted by social scientists which have repeatedly shown that citizens who support the space program are one-and-a-half times more likely to vote and to contact their elected representatives in Congress or the Administration than are those inclined toward less spending on space. Professor John Miller of the University of Chicago has concluded from his studies that there are about 14 million Americans strongly interested in the space program. Our members are the core of this group.

Now the results of the opinion poll. I will present the statement to which they were asked to respond, and the average response. Here are the results:

>Unmanned space flight is more cost-effective than manned space flight: 4.4;

>NASA should concentrate on unmanned activities: 2.7;

>NASA should be abolished and let the

private sector take over all civilian space activities: 1.9;

>NASA should be the operator of the Space Transportation System: 6.8;

>Congress should change NASA's charter to allow it to add operations to its R&D role: 7.1;

>NASA should let private industry take over all space applications research and development: 3.6;

>NASA should concentrate on technology development and leave pure science to other agencies: 3.2;

>The U.S. should cooperate more with the Soviet Union in space: 6.1;

>The U.S. should cooperate more with Western nations in space: 8.0;

>Competition from foreign space programs will be an important threat to the U.S. within the decade: 6.9;

>The Reagan Administration is a strong supporter of space: 3.4.

In addition to the foregoing items on the civilian space program, we also asked four questions about our nation's military space activities:

>NASA and DoD should cooperate more: 5.4;

>The Shuttle is primarily a military tool: 3.3;

>The U.S. should begin a program to build laser battlestations in orbit: 5.7;

>The U.S. should continue its development of an antisatellite weapon:

7.0.

Finally, we asked a question much debated currently about the future of the space program:

> We should develop a manned space station as a national goal by the year 1990: 9.2.

This last response is the most positive of the entire survey.

We also asked about their level of interest in various aspects of the space program, using a scale on which 1 meant they had no interest, 5 meant moderate interest, and 10 meant extreme interest. Three high-interest areas are noteworthy:

*Space stations: 9.3;
*Planetary exploration: 9.1;
*Space spinoff technology: 8.2.

These results tell us much about what the informed American general public thinks about our national space program.

Now let me turn my attention to the budget for Fiscal 1984 proposed by the Administration, in the light not only of the foregoing survey, but also of the comments we receive from our members and the general public in the dozens of speeches and radio and television interviews we do each year. I will address specific items roughly in the order they occur in the budget submission.

The Reagan Administration is to be commended for finally realizing the benefits of a strong space program, and for proposing increased funding. Even so, the reductions or insufficient increases of the past decade leave NASA about where it was several years ago. It is regrettable that each Administration has to go through this learning process while the civilian space program languishes.

The agency puts a proper emphasis on getting the Space Transportation System operational, but at the cost of consuming a huge proportion of the total budget: STS consumes 49% of the total NASA budget, and 61% of the

Research and Development budget. Space Shuttle is a tremendous credit to the agency, and to the nation. It is well to remember that many of the problems and cost overruns that have occured and still occur are the direct result of underfunding in the early stages of the program. Despite much wishful thinking, there still is no such thing as a free launch.

I think it would be useful if the STS portion of the NASA budget were considered almost apart from the rest. Otherwise, the remainder of the budget risks being allotted only the funds left over after STS is subtracted from whatever total budget figure is considered politically viable.

The Space Science and Applications budget is encouraging in several aspects. Continued funding for Space Telescope and the Gamma Ray Observatory is important; these new eyes on the universe are two of the most exciting research projects in all of science for the next decade. They will give us a new view of the marvelous universe of which we are a part. The new philosophy of the Explorer programs is also encouraging: a fund is set aside for this class of research, the individual projects to be determined by the people most qualified to do so: NASA and the research community.

The continuation of the Galileo project to Jupiter is extremely important. The new start for a Venus Radar Mapper is hopefully an earnest of the Administration's intention to support well-conceived, focused, and cost-effective planetary exploration. On the negative side, the reduction in the Research and Analysis line item will mean that we may not be able to handle adequately the data coming back from our continuing and new space probes. According to the Solar System Exploration Committee, the decrease in funding for this line item will eliminate the work of about 30 senior scientists and consequently about 150 graduate students. The SSEC has recently issued its recommendations calling for a funding scheme for planetary research similar to the Explorer Program ; this is a very salutary proposal which deserves your support.

Some other items in the budget are of concern. First, the decrease in the Materials Processing in Space budget will mean that we may have to concede superiority

in this potentially rewarding field to the Soviets and Japanese. Second, the Administration has once more reduced the funding for Technology Utilization by more than 50% from last year's appropriation. NASA is chartered to spread the results of its researches as much as possible; this cannot happen if businessmen outside the ranks of NASA contractors can't find out what spinoff technologies might be of aid to them. This line item should be restored to at least last year's figure.

On the bright side, I am happy to see a small but continuing effort on ion propulsion. Though the adoption of the Centaur upper stage eliminates some of the near-term uses for this innovative technology, it is a capability we will need in the future.

One major item I believe is missing from the budget is funds specifically earmarked for study of the uses of a space station. I am not now advocating setting a space station as a national goal--or even a NASA goal. I do think, however, that we are not studying intensely enough or quickly enough whether or not we do need a space station, and how much one (or more) would cost. I have read in the trade press that the Office of Science and Technology Policy opposes more intensive study of a space station because they are afraid such studies will produce a constituency which will pressure the government to commit itself to such an endeavor. If true, such fear of having to engage in a rational debate over the merits of the project once the studies have provided facts, is surely not a way to determine national policy.

There is an additional task that Congress should give NASA the funds to accomplish: by Public Law 96-344, the agency is mandated to preserve its historically-important sites. There are a few sites of preeminent importance; NASA and the Air Force on whose property many of the sites lie are financially unable to save our legacy. We are living in a watershed time in history. Had someone thought to preserve the pier from which Columbus set forth on his voyages of discovery, certainly the site would now be the destination of reverential pilgrimages. A similar locale is the pad and launch tower from which the first American astronaut soared into space. The tower is in danger of collapse within the next couple of years if nothing is done.

Since Congress gave NASA the mandate to preserve its historical sites it should thus give the agency the additional funds to do so and not expect the agency to find funding in its already-constrained budget.

NASA and the Subcommittee would also seem to be the best places to begin the study of how private firms can undertake space activities. Further, I urge your debate on the bill introduced by Congressman Akaka on this subject. Last year, when Space Services of America, Inc., wanted to launch its sub-orbital test flight, it found more than half a dozen government agencies that could say "no" to the flight, but not one authorized to say "yes." This situation must change so that there is an agency that can authorize private space launches.

Finally, let me set the proposed civilian space budget of $7.1 billion in its context as part of the proposed national budget. The civilian space budget is only Ø.84% of the Federal budget. Put another way, the interest on the national debt is 14.3 times the NASA budget. Put still another way, the civilian space program cost each taxpayer about $66 a year; that is, the NASA budget is about equal to the amount citizens spend each year on radios, televisions, and music players--equipment which would not be available to them without the benefits of spinoff from space technology.

Spending on the civilian space program can do much for the nation in the way of jobs, economic benefits, national morale and prestige. The employment it produces reduces demands on the public coffers for social spending. In order to document some of these benefits, I append a copy of an article I wrote recently for a national magazine and I ask that it be included in the record.

Mr. Chairman and Members of the Subcommittee, thank you again for this opportunity for the National Space Institute to represent the public's views.

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RATIONALE FOR A STRONGER UNITED STATES CIVILIAN SPACE PROGRAM

by
Mark R. Chartrand, Ph.D.
Executive Director
National Space Institute
Washington, D.C.
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The United States is in serious danger of losing its lead in space technology--and indeed has lost it in some areas, despite the fact that for a very small additional investment of government funding that lead could be maintained. There are substantial benefits of investment (which implies consequent return) in space technology in the fields of employment, industrial productivity, the national balance of international trade, general knowledge and intellectual endeavor, education, public spirit and moral, the quality of life, national defense, and international prestige.

The space program encompasses every area of high technology research and development. It is the driver for many of our cutting-edge industries. Funds invested in space spending are not spent in space, but on Earth. They go into the pockets of companies and thence to their employees. It is not that we as a nation can either spend for space research and development or spend on social programs. Both can be done, and spending on such high-productivity activities as aerospace will reduce the need for social support programs, such as unemployment compensation.

Currently less that 1% of the Federal budget is spent on all civilian (NASA) aerospace research and development. During the "crash program" of the mid-1960s, the figure was over 4%.

The space program is one of the leading high technology industrial areas of economic activity in the nation.

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While economics is less than an exact science, many econometric studies have given indications of the benefits to be derived by the nation from such government investment. These benefits accrue not just to the aerospace firms and their related suppliers, but to the average citizen.

The space program provides employment. An estimate is that for every $1 million spent in this area, 30 direct jobs and 70 indirect jobs are created where they did not exist before. Further, funds invested in high technology areas such as space return to public coffers 10- to 15-fold in the form of taxes, new jobs, balance of trade, productivity, new products and industries, and savings from reduced requirements for social support programs.

The space program provides substantial improvements in industrial productivity that affect all areas of business. Two-thirds of U.S. industrial productivity growth is due to technological advance spurred by research and development. Part of this comes from improved industrial processes, part from new products. A very critical part comes from improvements in worker training and performance. One study estimates that the manpower training benefits of large research projects is greater than the direct technological benefits.

We need not believe only our own economists. A European study of the results of contracts by the European Space Agency (ESA) concludes that benefits over and above the direct rewards of the contract accrued to the contractors and their suppliers amounting to 2.7 times the funds invested by ESA in the contracts. No estimate was made of the further benefits to the general economy. Of the indirect benefits, 22% were improvements to technology, 26% were commercial benefits not necessarily related to the contract purpose, 17% were benefits derived from improved organization and methodology, and 35% were from improvements in work factors.

Research and development expenditures often have long lead times for payback. In the ESA case cited above, one-quarter of the benefits accrued six or more years after the expenditure. This emphasizes the need for sustained and predictable funding. The current problems

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of poor technological literacy among our citizens, low productivity, and our decreasing leads in high technology fields, are the result of neglecting research and development in the early 1970s--a large part of which is the space program. The General Accounting Office states flatly that "...the US's conservative approach does not compare favorably to specific long-term plans of the members of ESA..." America is losing its lead.

Investment in space R&D provides great national economic benefits. According to another study, "The aerospace industry has been the second largest contributor to positive net [international] trade in the U.S." While the space program is only a part of "aerospace" it is the leading edge. More and more private firms are beginning to see business in space, ranging from launch services, to financing, to insurance for spaceflight, to space law and diplomacy, to operation of satellites for prospecting.

The civilian space program also enhances national security, by providing new technology which can be adapted by the military forces. In addition, the success and openess of the U.S. civilian space program enhances national prestige abroad, and confidence at home, providing unquantifiable but important benefits when our leaders consider national policy or negotiate international agreements.

The space program provides knowledge. In the 1960s it was the major influence on improvements in education--particularly technical education but spreading out into all areas of intellectual endeavor. Every part of human life is touched by the space program. The U.S. is well behind the Soviet Union in the quality and quantity of technical education. A greater national R&D effort produces a larger informational base upon which to draw, and in a positive-feedback way enhances R&D even more. Not only do benefits come to the traditional educational system, but improvements in such areas as management techniques, systems organization, and educational technology have substantial benefits for all of industry and society.

While the pure research of such activities as planetary

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and stellar astronomy are not easily quantifiable, it is historically demonstrable that such intellectual exploration is not only the hallmark of a great society, but its duty to the rest of mankind on the planet.

The space program provides an increase in the morale of the nation's citizens and in their quality of life. No activity can be justified solely on the basis of its spinoff, but the space program has provided technologies and techniques that save lives. Many people are living today who would have died years ago without the benefits of space spinoff. Many, many others are leading almost normal lives with new prosthetic joints and other aids, who would have before been consigned to reduced activity and more dependent upon social support funding. The best social security is a strong economy and the ability to repair the ravages of living on the human body.

The space program contributes to the everyday quality of life by supplying increased availability of education and recreation through communications satellites. It contributes new natural resources through remote sensing satellites. One estimate is that satellites save users in agriculture, shipping, and fishing at least $172 million each year. The space program provides a better environment for us to live in: in just one example, the state of Texas found it could survey its lands from satellite for a fraction of the cost and time of a ground or aerial survey.

Space contributes to the spirit of Americans. Witness the phenomenon that 300,000 people will drive through the night to the middle of the Mojave Desert for a 30-second show of the Space Shuttle landing, or that millions line beaches to watch launches. This mass interest must be turned into a constituency that not only understands why their representatives in the Capitol vote to increase space investments, but insists that they do so.

Industrial societies have a long and generally successful history of seeing that one important role of government is undertaking the high-risk, long-leadtime ventures that business cannot afford to do. They have traditionally seen national transportation systems and communications systems as vital to their existence. The space program

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is a logical extension of this trend. For example, NASA developed communications satellite technologies in the 1960s; these were later transferred to the private sector where they now make possible a a $2 billion a year industry. Eventually these firms will return to the government more in taxes on their profits (if they have not already) than tax monies were spent to develop the technologies.

The civilian space program continues to contribute enormous benefits to the nation, without sacrificing other national programs. Expenditures in R&D are investments similar to other investments in that they return more than was put in. They are investments in a rewarding future. A nation which refuses to invest more than 1% of its resources in its own future will not have one.

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REFERENCES

(1) Science Application, Inc., "Space Industrialization--an Overview," Final Report, NASA Contract NAS8-32197, 15 April 1978.

(2) Los Angeles Section of the American Institute of Aeronautics and Astronautics, "A Critical Assessment of the Status, Future, and Funding of the U. S. Space Program," April 1982.

(3) E. F. Denison, "Accounting for United States Economic Growth, 1929-1969," Brookings Institution, Washington, D.C., 1974.

(4) J. W. Kendrick, "Sources of Growth in Real Product and Productivity in Eight Countries, 1960-1978," Office of Economic Research, New York Stock Exchange, New York, 1981.

(5) Jordan D> Lewis, "Technology, Enterprose, and American Ecoromic Growth," Science, v. 215, pp. 1204-1211, 5 March 1982.

---more---

(6) John Irvine and Ben R. Martin, "The Economic Effects of Big Science: The Case of Radio Astronomy," in "Economic Effects of Space and Other Advanced Technologies," T. D. Gayenne and G. Levy, editors, European Space Agency Publication SP-151, September 1980, p. 103ff.

(7) Goetz Niederau, "Economic Benefits of ESA Contracts" Final Report, ESA Contract 2905/76/f/WMT(SC), July 1978.

(8) European Space Agency, "Economic Effects of ESA Contracts," ESA Publication BR-02, October 1979.

(9) General Accounting Office, "U. S. Must Spend More to Maintain Lead in Space Technology," Report FGMSD-80-32, 31 January 1980, p. 3.

Mr. VOLKMER. Thank you very much.

At this time I recognize the gentleman from Florida, Mr. Nelson, for questions.

Mr. NELSON. Well, I thought that the results of your survey among some 12,000 people were most illuminating. Can you suggest to me how we can get that message across to OMB?

Mr. CHARTRAND. We try. We speak to millions of people. We mailed 400,000 letters last year. We do lots of interviews. We do send them copies of this testimony. There will be copies going to OMB and the other people in the White House. The number of phone calls that come to the White House is quite large during the Voyager program, for instance, and about a year ago when the NASA budget was in serious danger.

All the letters that come into the White House, however, if they even get counted, simply get boxed up and sent to NASA to answer. So it is almost a burden on NASA for citizens to express their positive feelings to the White House. I think all we can do is keep hammering away. It is going to have to be kind of a Chinese water torture, just try to erode it.

I just think if you keep saying it loudly and long enough that somebody is going to have to listen. They have certainly come to realize the importance of the space program on the military side. I think they have got to realize the importance of space in leading productivity, economic benefits, employment, reduced need for social services, all kinds of things. And the fact that the space program of the 1960s was the only time I can think of in history when we had major technological innovations and it wasn't a time of war. But how we can actually get to OMB, I think we just have to keep hammering.

I think the Congress has the capability of sending a very strong message to the administration. I certainly would urge you to do so. I think the foundation and growth of the Congressional Space Caucus is a salutary thing. And I think you should just keep rubbing their noses in it.

Mr. NELSON. From your vantage point in the National Space Institute, do you get a number of comments from NASA officials pri-

vately that are one thing but publicly, in hewing to the OMB line, are another thing?

Mr. CHARTRAND. Sure. I can't say from whom, but sure. We hear a lot from inside NASA. I don't think it is any secret that OMB was massaging the testimony you heard on Tuesday up to about 2 hours before you heard it. Things like that. So, sure.

Unfortunately, also this has produced somewhat of a trench mentality at NASA. Some of the guys are so afraid of sticking their heads up, because they will get shot off by OMB, that they are loathe to raise anything. That is unfortunate.

Mr. NELSON. That really is. You said it probably even better than I could. You used the word "trench" mentality. I was going to ask you to what degree you see the effect of OMB intimidation upon NASA.

Mr. CHARTRAND. I think not just the current OMB, but the trends of the last decade, exacerbated by the current OMB, I think has been intimidating. I think that is an excellent word for it.

Mr. NELSON. Trench mentality.

Mr. CHARTRAND. Stick your head up, you get it shot off. That has happened.

Mr. NELSON. Why do you think some members on a scale of 1 to 10—of your membership—would rate so high, 9.2, the space station?

Mr. CHARTRAND. I think because they identify with the excitement of it for one thing. I think they remember the days, some of them anyway, who were alive then, remember the exciting days of the 1960s'. There was a marvelous morale, a feeling in the country at that time, a great feeling throughout the Nation. But they also, I think, identify with people. That is one reason manned space flight receives such support. People identify with people.

They also see that most of the things, like the biomedical benefits, that come out of the space program are a direct result of the manned space program, not the automated space program, the robots, planetary probes, and so on. I am not denigrating them. I am simply saying the people like to see people doing things. It is a little like identifying with the hunters, trappers, explorers, and soldiers who went out and colonized and explored the western part of this country a century ago.

Mr. NELSON. This is fascinating to me, Mr. Chairman. But I will just stop right here, and would like to ask a few more questions later on.

Thank you.

Mr. VOLKMER. Thank you, Mr. Nelson.

At this time I will recognize Mr. Bateman for 5 minutes.

Mr. BATEMAN. Thank you, Mr. Chairman.

Dr. Chartrand, I am very impressed by the results of the survey, also, and appreciative of your observations about the trench mentality that may exist. Of course it is a lot easier to sit up here, because of some particular proclivities we may have on these aspects of what the Government does and how it spends its money than perhaps someone who is looking at the total perspective of how much money is spent and where it is spent.

It would be helpful if you could supplement the questionnaire with perhaps some alternatives as to where might we get the addi-

tional money, or where should we cut back in order to have the additional money for these things. Do you have any comments as to whether or not that is a part of this trench mentality which arises when someone is dealing with overall spending levels, ordering of priorities? And other people have other priorities, and even among your membership. If told to put more here, you have got to take from somewhere else. Where do we make the suit fit that cloth?

Mr. CHARTRAND. I quite understand the problem. It is the President's problem, and OMB's problem, and all of our problem as taxpayers. One thing you do have to keep in mind, though, is the extremely small amount of the NASA budget compared to everything else. If, as some people suggested a decade ago, you abolish NASA and turn it over to social programs, I don't think you would ever see that money surface.

When you continually read in the paper that like a few years ago, I believe HEW, in the last year admitted it lost $10 billion—that was two NASA budgets—just to accounting errors. I think if you tried to clean up some of those accounts you could produce a really good space program out of just sweepings, quite frankly. Eighty-four one-hundreds of 1 percent of the Federal budget is a very, very small amount, $66 per taxpayer. I think that our people see that that really is a very small amount—$7 billion sounds a lot bigger.

Also, with a lot of people in the country, particularly the people who don't know very much, they see the NASA budget, and NASA is perhaps the second most visible thing the Government does besides the Department of Defense. It is so spectacular and spectacularly successful that people assume it must spend tremendous amounts of money. We have asked people, and people who don't know anything about the space program assume the NASA budget is second only to the Department of Defense, whereas in reality the Department of Defense spends one NASA budget every 11 days.

Mr. BATEMAN. Well, I will go back to where I began. You and I are not in disagreement. I think perhaps we would also agree fully that what we spend through NASA is very well spent, and the ultimate return on it is more of an investment than an expenditure. There remains, however, the fact that NASA has its constituency, such as your organization. And thank heavens it does, because it is a very helpful constituency to have.

But these other programs, where money is wasted and admittedly paid pursuant to mistake or fraud, have constituencies apparently that are very large and very, very, shall we say, influential in these halls that we occupy. Any help you can give us by suggesting transferral of emphasis would be most helpful.

Mr. CHARTRAND. Thank you for your comments, sir. I have attempted to document some of these in the addition I supplied to the committee for the record.

Let me say simply that the space program is now getting to the point where it is mature. And there is almost no sector of human life not touched by the space program. I think one has to make the point continually that there are people living now who would be dead without the benefits of the space program. There are people living much more active, useful, healthy, happy lives who would be

confined to a much more restricted life without the benefits of the space program.

And to show people it is not a case of either/or, it is a case of doing both. As someone said, Queen Isabella did not wait until poverty was stamped out in Spain before dispatching Columbus. Had she, America would not be discovered yet, except by Spain.

Mr. BATEMAN. Queen Isabella had a slightly different constituency.

Mr. CHARTRAND. That is true, too.

Mr. BATEMAN. I don't think she was elected.

Thank you, Mr. Chairman.

Mr. VOLKMER. The Chair recognizes the gentleman from New Mexico, Mr. Lujan.

Mr. LUJAN. Thank you, Mr. Chairman.

We are all proponents, I guess, of the space program. That is why we chose to be on this committee. But I do agree with Mr. Bateman. We have a different kind of responsibility. As a matter of fact, I was discussing this morning about what should be done concerning the fifth orbiter and the spare parts. You can see down the line that if not enough money is put into production, whether in spare parts or the orbiter, your capability is going to go down.

At some point, I don't think we will be able to get along for the rest of our lives with just four orbiters. That is for sure, particularly when we have a space station and we are making our regular rounds. But then you come face to face with the problem of eliminating the deficit, which is my main commitment.

Now how does that square with putting in an additional $100 million, which NASA cut out, for the replacement of spares? How does that square with putting on another $100 million with my main commitment of a balanced budget, or elimination of the deficit? Because it is scarey when you look at the deficits projected in the next 4 years: $180 billion for 1984, or some such figure, and about the same for 1985. How can we ever survive?

I think we can probably survive without a few spare parts for the shuttle. But I don't know that we can survive a $180 billion deficit every year. So it is difficult.

Mr. CHARTRAND. Yes, sir, it is. I share your concern about the deficit. I would submit, however, that the best solution to that is probably a strong economy. And the space program has been the leader in productivity. It is the second biggest contributor to positive balance of international trade. Studies done by the Europeans, which I mention in the supplement I submitted to the committee, demonstrated that contractors get something like 2.7 times the actual cash amount of a contract, from a space contract, in terms of other types of benefits.

That was done by the Europeans. We don't have to believe our own economists that the space program is a significant contributor to industrial productivity and economic well-being of this Nation. I think that is the case we can make.

Mr. LUJAN. Where would you put the additional moneys in NASA?

Mr. CHARTRAND. I think it is important that we get the space shuttle program running and on its own. General Abrahamson, whom you heard eloquently talking on Tuesday, talks about the

problems the engines are having now is a problem because there aren't any spares. There wasn't any money to make spares.

Mr. LUJAN. The problem is a refurbishing of those engines?

Mr. CHARTRAND. Yes.

Mr. LUJAN. They have to redo them to get more power out of them than if they had kept them at the same power level they were using with Columbia.

Mr. NELSON. No, no.

Will the gentleman yield?

Mr. LUJAN. Yes.

Mr. NELSON. As I perceive it, these are new engines developed to a higher percent.

Mr. LUJAN. That is correct.

Mr. NELSON. It is not taking the old Columbia engines.

Mr. LUJAN. No; I understand that but it is the same design of engine, same basic——

Mr. NELSON. A new design.

Mr. LUJAN. Total? Just upgraded I thought.

Mr. NELSON. There are considerable design changes since they moved the power up.

Mr. LUJAN. You are asking them to do more. You know that at this phase in the program you are going to have more problems if you ask that. How did we get on this?

Mr. CHARTRAND. The problems we have now are due to the initial underfunding of the shuttle program from the time it was voted on.

Mr. LUJAN. We have enough engines. Why would you say we are having problems with the engines? I saw five engines at the Mississippi test center the other day. We only need three to put the enterprise up.

Mr. CHARTRAND. That is correct.

Mr. LUJAN. So it is not a shortage of engines. It is a shortage of reliable engines, I guess.

Mr. CHARTRAND. That is certainly true right now. But as to your question as to where more money could be spent, I certainly think that we should keep our science strong simply because that is an important consideration. I think that those R&D and science efforts are extremely important. I think the shuttle deserves to be made into the first-class spaceship that it really is.

And I think that if we went back to what NASA——

Mr. LUJAN. Would more money make it a better shuttle?

Mr. CHARTRAND. History has shown us that if you try to do cutting-edge technology on a shoestring, you invariably get into trouble.

Mr. LUJAN. $7.1 billion is not a shoestring.

Mr. CHARTRAND. It depends upon how big a program you are running. The Apollo program cost $24 billion in dollars at that time.

Mr. LUJAN. I just don't know what to tell you. I would love to just be able to say to NASA, how much money do you need, and here it is. We can't do that, obviously, because of other concerns. And I don't know what the answers are, Mr. Chairman, but I don't have anymore questions.

Mr. VOLKMER. Thank you.

Mr. BATEMAN. Mr. Chairman?

Mr. VOLKMER. Yes.

Mr. BATEMAN. Dr. Chartrand made reference to a supplement which I don't have before me.

Mr. CHARTRAND. Mr. Smith has some copies of that, sir. He asked me to submit five copies to the committee. I did so.

Mr. BATEMAN. Fine. I just wanted to make sure I got one.

Mr. VOLKMER. Those will be furnished if you don't. We do have copies now.

I now recognize Mr. Chandler for 5 minutes.

Mr. CHANDLER. No questions, Mr. Chairman. Thank you.

Mr. VOLKMER. Then I have a couple of questions. It looks like you will be able to make your plane yet.

Mr. CHARTRAND. Thank you, sir.

Mr. VOLKMER. Your survey indicated that NASA should operate a space transportation system. How does this finding relate to your testimony that implies one Government agency should authorize private space launches? Are you in favor of allowing industry to operate expendable launch vehicles in competition with the shuttle operations?

Mr. CHARTRAND. Yes, sir, I am in favor of having private industry doing as much as they can. But I don't think that we are going to find, once the shuttle really gets flying and once people begin, in this decade, to see the benefits of space, that there is going to be all that much competition internally. I think you are going to need all the launchers, essentially, you can get. I think competition between individual private firms, whether it be Space Services, Art Technologies, McDonnell Douglas, whoever comes up; but, yes, I think private industry certainly should get into this.

We certainly need to find a way, and I am not saying necessarily that Congressman Akaka's bill is the absolute answer, but we certainly need a way to have private firms authorized to conduct launches.

I might also say, by the way, that I think we are going to have to take a very serious look at one of the treaties we signed, the International Liability Treaty, and see whether we should pull out of that treaty or have it renegotiated to allow private firms to do so.

Mr. VOLKMER. Now, in order to get a clear picture of NASA's R&D budget and activities, do you think the space transportation system should be spun off from NASA and operated separately?

Mr. CHARTRAND. Not at this time, sir. I am not prepared to say if it ever should or when it should. But certainly not right now. It is still an ongoing R&D effort even when it becomes operational.

Mr. VOLKMER. You are not espousing that that system be commercialized?

Mr. CHARTRAND. Not at this time certainly. I don't think there is enough data available at this time to say when it can be, if ever.

Mr. VOLKMER. You mention your concerns for the reduction in funding for materials processing. What role should NASA play in the materials processing arena?

Mr. CHARTRAND. With the exception of the McDonnell Douglas study I think materials processing in space right now is mostly a question of scientific research. It is not yet development. I think that is a role for NASA because that is the sort of thing it is set up

to do. It should be funding some of that long leadtime, high risk, pure research in material sciences in this new environment.

Mr. VOLKMER. You are then saying, basically, that private industry isn't going to get into the R&D effort as far as materials processing is concerned? To any great extent, anyway.

Mr. CHARTRAND. They are to some extent. McDonnell Douglas and others, though, has. However, the GTI agreement recently fell apart simply because they found a lack of customers, as I understand it. However, there are other firms which are doing similar things, not joint endeavor agreements. John Deere, for instance, is going to be using zero-g facilities initially in an airplane, hopefully eventually in a shuttle, to study some basic material sciences on solidification of cast iron. I think that is an ideal way.

Right now that is a no-cost thing for NASA. But NASA could be doing similar things not of immediate industrial applicability.

Mr. VOLKMER. Now has NSI made any surveys that show the results of NASA's technology utilization program?

Mr. CHARTRAND. Surveys, no, sir. But we do know that basically what that is is spinoff.

Mr. VOLKMER. Right.

Mr. CHARTRAND. Under that rubric, it is the third most important component of the space program to our members and the people who write us unsolicited letters, to send us information about what is happening, about what NASA is doing, what we are getting out of the space program. I might also point out the continued popularity of the spinoff series of books NASA produces every year. So although we have not done a normal survey, I can tell you simply from talking to people and interviews and letters that it is a matter of very, very great concern to the public.

Mr. VOLKMER. Just a sidelight and to continue the thoughts behind Mr. Bateman's and Mr. Lujan's questions of the budget and where the money comes from, I was just wondering if you ever put in your survey if some of those people would be willing to pay additional money in tax in order to have these types of programs?

Mr. CHARTRAND. The answer is yes, sir.

Mr. VOLKMER. Do you believe——

Mr. CHARTRAND. We have never asked that question, but we have had the answer submitted to us without asking.

Mr. LUJAN. If the gentleman would yield, that is an activist-type of person, though.

Mr. CHARTRAND. Yes, I agree, sir.

Mr. LUJAN. I don't think you have that across the broad spectrum of the American taxpayer.

Mr. CHARTRAND. No; certainly not.

Mr. VOLKMER. I would say most people out there are going to tell you they don't want to pay any more taxes for anything, period.

Mr. CHARTRAND. Sure.

Mr. LUJAN. Maybe not for the space program.

Mr. CHARTRAND. Yes; I am not certain about that. I am not certain about that.

Mr. VOLKMER. If the local people won't increase it for their own education or their own students, which happens many times all over the country on your local school boards and things like that, it

makes you wonder whether they would. That is a basic and I think we all recognize it.

Mr. BATEMAN. Mr. Chairman, would you yield for a moment? Perhaps we should propose a space tax.

Mr. NELSON. Jack Kemp would love that.

Mr. VOLKMER. He is all spaced out.

Mr. CHARTRAND. We will be asking our members, making a similar survey. As a matter of fact, that survey may be extended this fall. We are talking with a national science magazine about conducting the survey for the general public at the same time. And that is an excellent question that we might ask. And I would hope perhaps, sir, you might have us back again next year to give you an answer to that question.

Mr. VOLKMER. I think most of us recognize the problems with the reduced budget and the reduced budget's effect on our total space program. I see Mr. Walker has joined us now. As I understand it, you still have about 3 minutes before you have to leave.

Mr. CHARTRAND. There is a countdown going.

Mr. VOLKMER. Right. He has a plane to catch, Mr. Walker.

Mr. WALKER. Thank you, Mr. Chairman. I will be brief.

Can you outline for me what your membership generally had to say about commercialization of outer space and moving rapidly toward more commercial development in our outer space activities?

Mr. CHARTRAND. We didn't ask a specific question like that. The indications from the questions we did ask and comments we also get is that they would like to see private industry get into the space program as rapidly as they can. But they don't think that things should be spun off, forced on private industry before private industry is willing to take them. That is going to fall flat on its face.

Mr. WALKER. You don't have an indication as to how they make a division between the two?

Mr. CHARTRAND. No, sir. And I am not sure how, for it is a very complex subject. Nobody even knows what the word "operational" or "mature" means in this case. I don't think that the general American public has the information they need to make that kind of a decision, and as a matter of fact I am not even sure at this point the administration or Congress does. It is a very, very complex topic.

Mr. WALKER. Well, the concern I have, and then I will allow you to catch your airplane, is that if we hadn't gone about, for instance, spinning off to some of the communications satellite programs, we would still be a decade behind where we are right now. The very fact that we began to commercially sell those services and basically have the industry out there trying to make it, is the reason why we are on such a fast track in that particular phase of the space industry.

If we don't see some of those opportunities developing and don't basically force business to take a look at how they are going to sell some of these services, then we will continue to be in a situation where commercialization will always lag behind because government has other priorities.

Mr. CHARTRAND. There may be some component of having to push the birds out of the nest. But do recall, however, that indus-

try did not pick up the 30/20 gigahertz research when NASA dropped it. Only recently now is NASA getting back into it again and industry is finally realizing they need that technology. The Japanese just a month ago launched an operational satellite using that frequency band.

Mr. WALKER. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you very much, Dr. Chartrand.

Mr. CHARTRAND. Thank you, sir.

Mr. VOLKMER. We appreciate your testimony here today. Now we will hear from Dr. Alan Lovelace, and also accompanied by Dr. Stanley Rosen.

[A biographical sketch of Dr. Lovelace and Dr. Rosen follows:]

DR. ALAN M. LOVELACE

Effective 27 August 1982 Dr. Lovelace was made VP-Productivity & Quality Assurance.

Dr. Alan M. Lovelace joined General Dynamics Corporation as Vice President-Science and Engineering in July 1981. He had served as Acting Administrator of the National Aeronautics and Space Administration since January of 1981.

Dr. Lovelace joined NASA in 1974 as Associate Administrator for the Office of Aeronautics and Space Technology. He was named Deputy Administrator in June 1976 by President Ford.

Since entering federal service with the U.S. Air Force in 1954, he has held many research management positions. He served at the Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio, from 1954 through 1972, having been named Director in 1967.

From 1972 to 1973, he served as Director of Science and Technology with the Air Force Systems Command, Andrews Air Force Base, Washington, D.C. From 1973 to 1974, Dr. Lovelace was Principal Deputy Assistant Secretary of the Air Force for Research and Development.

Dr. Lovelace retired as Deputy Administrator of NASA in December 1980 but stayed with the Administration through the first flight of the Space Shuttle Columbia and the appointment of a new administrator.

Born in St. Petersburg, Florida, in 1929, Dr. Lovelace received bachelor's, master's and doctoral degrees in chemistry from the University of Florida. Awards he has received include the Presidential Citizens Medal, the Department of Defense Exceptional Service Medal, the Air Force Decoration for Exceptional Service, the National Civil Service League Career Service Award, and the Office of Aerospace Research Award for Outstanding Contributions to Research.

He is a Fellow of the American Institute of Aeronautics and Astronautics and the American Astronautical Society, and is a member of the National Academy of Engineering, Air Force Association, Sigma Xi and Phi Beta Kappa.

Married to the former Kathryn Logan of Bridgeton, Connecticut, the Lovelaces have two children.

DR. STANLEY G. ROSEN

Stanley G. Rosen is Chairman of the Technical Committee on Space Systems of the American Institute of Aeronautics and Astronautics, and is a member of the AIAA Public Policy Committee. He received his BS degree from the U.S. Air Force Academy, holds masters degrees from the Massachusetts Institute of Technology and the University of Southern California and completed his doctoral work in Engineering Science at the University of Stuttgart, Germany. He has held engineering, management and policy positions during various assignments with the National Aeronautics and Space Administration, the U.S. Air Force and the German Aerospace Research and Test establishment, and has served on the staff of the Committee on Science and Astronautics of the U.S. House of Representatives. He is currently on active duty with the U.S. Air Force.

STATEMENT OF DR. ALAN LOVELACE, VICE PRESIDENT FOR PUBLIC POLICY, AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS (AIAA), ACCOMPANIED BY DR. STANLEY ROSEN, CHAIRMAN, SPACE SYSTEMS TECHNICAL COMMITTEE, AIAA

Dr. LOVELACE. Thank you, Mr. Chairman.

Mr. VOLKMER. Dr. Lovelace, your testimony will be made a part of the record. You may read it or give us a synopsis, however you so desire.

Dr. LOVELACE. Thank you, Mr. Chairman.

Dr. Rosen and I are pleased to be here to testify on behalf of AIAA, which is a nonprofit technical professional society with over 34,000 members who are engineers, scientists, and students engaged in every sector of the aerospace profession from industry to government to the universities.

The institute's professional membership is divided into 68 sections around the country. To further scientific and technical advancement, we have 51 technical committees covering every aspect of the aerospace profession. Our testimony today does not necessarily represent a consensus of our membership, any more than one administration is a perfect representation of the will of all the people. Our testimony represents the expertise of a select group of our members who were given this responsibility by me in my capacity as vice president for public policy.

We welcome the opportunity to offer an outside perspective on our Nation's role in space. As we observe the 25th anniversary of the NASA, we recognize the need to build on our heritage and to maintain a balanced and dynamic civil space program within the fiscal constraints of the 1980's.

As we have consistently reported to this subcommittee in the past, the NASA program is, in our opinion, the wrong slice of the Federal budget in which to trim our Nation's relatively modest ongoing investment in research and development. To this end, last year we generally endorsed the level of NASA space activity proposed by the administration, while pointing out several areas where an increased investment was justified. We commend this subcommittee, as well as the entire Congress, for appropriating more resources in this area than were originally requested.

As President Reagan clearly recognized in his state of the Union address, we live in a country ever more dependent on technology for its strength and survival. We therefore feel confident that there are few ways to better invest in the Nation's future than in the civil space program, an area which today commands an exceedingly small portion of the Federal budget.

On the basis of this perspective we participated in the development of the national space policy statement released last July. Our submitted testimony contains an AIAA review of that policy, which we find generally acceptable.

There are two major areas, however, in which the administration's position falls short of AIAA expectations. As we mentioned in last year's testimony, and formally endorsed last May, the AIAA feels it is essential that the Nation now commit itself to an evolutionary program to establish and maintain a multipurpose facility

in low Earth orbit. Such an orbital capability would use and complement the space shuttle's ability to enable human operations in space. We believe eventual long-term habitation is a capability the United States should pursue. It would appear that the Soviet Union is rapidly moving in this direction.

The administration's policy commitment to "permanent space facilities" is ambiguous, however, and subsequent pronouncements by the NASA leadership and this year's budget submittal leave us somewhat uncertain as to the administration's current course.

In our opinion, a second needed policy element is a firm commitment to a specific national space program plan, complete with schedule milestones. Such a comprehensive statement of strategy has not yet appeared. Although we have taken no position as to the specifics of such a plan, we have repeatedly emphasized the need for long-term commitments to add needed stability to our efforts. As noted here last year, stability, itself, will go far toward insuring the vitality of U.S. accomplishments in space.

Mr. Chairman, we are prepared to offer more detailed commentary at a later date on current national space policy, should such a critique be requested. We will now review the proposed program in light of the commitments in stated national space policy, and our reaction to this guidance.

Seated with me today is Dr. Stan Rosen, chairman of the AIAA Systems Technology Committee who, in consultation with other technical committees, has prepared our testimony on which I have given my approval. As you have offered, I would like to ask that the complete statement be included in the record, and I would like to ask Dr. Rosen to present a few of the highlights contained in that statement.

Dr. ROSEN. Thank you, Dr. Lovelace.

Mr. Chairman, we have organized our remarks today into the areas of space science and applications, space research and technology, and space flight, which includes space transportation. We are pleased to see that, in each of these areas, the proposed program is consistent with avowed policy.

However, we are concerned this year, more than before, that the proposed budget falls far short of meeting the overall objective to which we have concurred: maintenance of leadership in space activities. In light of the considerations, Dr. Lovelace stated, we feel it is not unreasonable, in fact, we feel it is mandatory, that we advocate today a more aggressive civil space program than that which has been proposed by the administration.

Now turning to the specific areas. One year ago, NASA's space science program, particularly the planetary exploration program, was severely threatened. Your committee and the Congress responded, showing your commitment to maintaining U.S. leadership in space exploration. We commend your support and your restoration of vital funds to the planetary research and data analysis programs.

You have continued to recognize the value of basic research support. We believe it is consistent with your previous position to restore specifically the few million dollars to planetary research and analysis necessary to maintain a minimum viable program and to

continue the upward trend established in fiscal year 1983 in other areas of space science.

In the area of space and terrestrial applications, additions made to the communications budget in fiscal year 1983 for development and demonstration of advanced space communications technology are especially noteworthy. The current proposed course of developing and flying Ka-band—that is, 30/20 gigahertz—components and systems in an advanced communications technology satellite has our endorsement. This course should be followed using the most cost-effective method possible. However, we strongly believe that the United States must continue to develop this technology now with or without commercial participation.

I would now like to turn to the space research and technology portion of the budget. We have consistently pointed out that this is the area we consider to be the heart of NASA's and our country's future civil space capabilities. The 12-percent increase proposed here is a healthy sign for the future of the U.S. space effort. Technology base programs are up over 9 percent, and funding allocated to important space flight experiments has been increased by over $2 million over fiscal year 1983. We strongly endorse these trends.

Even in light of the overall increase in this area, however, examination of the specifics of the proposed research and technology budget indicates that funding may not be available for many needed programs.

The final area in which specific comment on the proposed space budget is in order is that of space transportation. The space shuttle program, an arduous technical and managerial challenge, is maturing rapidly. Many obstacles to cost-effective operation remain. We recognize that. But the United States can rightly be proud of this new capability.

We endorse steps to control STS operational costs, now being taken by NASA, which promise to improve program economies. We strongly support additional development work aimed at further reductions in launch costs and at improving utility of the overall space transportation system.

We are, however, disappointed that a specific commitment to maintaining an orbiter production capability has not yet been made. We recognize that such a step is expensive, and that clear analytical justification for a fifth vehicle cannot be made at this time on the basis of firm user commitments. Consideration of potential commercialization of expendable launch vehicles is another factor which clouds the picture and makes it even harder to clearly identify future STS traffic demand. However, as we noted last year, several factors lead us to believe that an investment now which retains the option for an additional orbiter would be wise.

We therefore support the strategy of acquiring spare parts in order to keep the cost of future vehicles within reach.

The advanced programs area of the space transportation budget continues to grow at a rate greater than that of the overall agency, but here again, in our opinion, is still desperately underfunded.

We endorsed development of an evolutionary space platform capability in last year's testimony and in our midyear assessment of space policy. We look forward to the completion of the current NASA/DOD studies of space station requirements and architec-

tures. These studies will help identify the proper path to achieve needed capabilities. We are concerned, however, by the absence in fiscal year 1984 of funds to continue communitywide assessment of this program, especially at the systems level. Maintenance of strong government and industry participation is essential to achieving evolutionary space capabilities, both manned and unmanned. Whatever the selected course, this teamwork should be maintained by continuing contractor systems studies.

In short, then, sir, these comments reflect our view that the advanced programs element should be significantly increased.

To summarize the major portions of our statement, there are six areas in which the AIAA recommends specific additions to the proposed fiscal year 1984 administration budget, and I would like to tell you what they are. First, shuttle science payload development; planetary research and analysis; flight support for the upper atmosphere research satellite instrumentation which is being developed; technology utilization; research and technology in the space area; and all the advanced space transportation programs. Now, as our statement indicates, in other areas we also feel that a more aggressive approach is both justified and necessary.

Mr. Chairman, as you can see, the AIAA believes, after thorough and careful review, that NASA is not being adequately supported by this administration, in light of today's needs, priorities, opportunities, and, yes, sir, constraints.

Mr. Chairman, 25 years ago your predecessors created a marvelous social invention, the National Aeronautics and Space Administration. In the last quarter century, the NASA has impelled and inspired our society to almost unbelievable heights of greatness. We trust this Congress will continue to fuel the fire of the American spirit and American capability by supporting a strengthened civil space program. As we noted in our statement on space policy released last May, and I quote:

> Nearly 500 years after Columbus opened a path to the New World, we can ensure that U.S. leadership in the exploration and utilization of space will bring maximum returns from the new world of space to the nation's citizens, and to all the peoples of the world.

That concludes our prepared remarks and, of course, we are ready to answer your questions. Thank you.

[The prepared statement of Dr. Lovelace and Dr. Rosen follows:]

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Statement to

Subcommittee on Space Science and Applications
Committee on Science and Technology
United States House of Representatives

by

Dr. Alan M. Lovelace
Vice President, Public Policy

and

Dr. Stanley G. Rosen
Chairman, AIAA Space Systems Technical Committee

American Institute of Aeronautics and Astronautics

March 3, 1983
(Abridged statement)

19-605 O—83——91

Introduction,

Dr. Alan M. Lovelace

The AIAA is a non-profit technical professional society with over 34,000 members who are engineers, scientists and students engaged in every sector of the aerospace profession from industry to government to the universities.

The Institute's professional membership is divided into 68 sections around the country. To further scientific and technical advancement, we have 51 technical committees covering every aspect of the aerospace profession. Our testimony today does not necessarily represent a consensus of our membership, any more than one administration is a perfect representation of the will of all the people. Our testimony represents the expertise of a select group of our members who were given this responsibility by me in my capacity as Vice President for Public Policy. Seated with me here today is Dr. Stanley Rosen, Chairman of the AIAA Space Systems TC, who in consultation with other technical committees has prepared our testimony, on which I have given my approval.

Statement by
Dr. Stanley G. Rosen

We welcome the opportunity to offer an outside perspective on our nation's role in space. As we observe the 25th anniversary of the NASA, we recognize the need to build on our heritage and to maintain a balanced and dynamic civil space program within the fiscal constraints of the 1980's.

As we have consistently reported to this subcommittee in the past, the NASA program is, in our opinion, the wrong slice of the federal budget in which to trim our relatively modest on-going investment in research and development. To this end, last year we generally endorsed the level of NASA space activity proposed by the Administration, while pointing out several areas where an increased investment was justified. We commend this subcommittee, as well as the entire Congress, for appropriating more resources in this area than were originally requested.

As President Reagan clearly recognized in his State-of-the Union Address, we live in a country ever more dependent on technology for its strength and survival. We therefore feel confident that there are few ways to better invest in the nation's future than in the civil space program, an area which today commands an exceedingly small portion of the federal budget.

In that light, we participated in the development of the national space policy statement released last July. Our submitted testimony contains an AIAA review of that policy, which we find generally acceptable.

There are two major areas, however, in which the Administration's position falls short of AIAA expectations. As we mentioned in last year's testimony, and formally endorsed in May, the AIAA feels it is essential that the nation now commit itself to an evolutionary program to establish and maintain a multi-purpose facility in low earth orbit. Such an orbital capability would use and complement the space shuttle's ability to enable human operations in space. We believe eventual long-term habitation is a capability the U.S. should pursue. The Administration's policy commitment to "permanent space facilities" is ambiguous, however, and subsequent pronouncements by the NASA leadership and this year's budget submittal leave us somewhat uncertain as to the Administration's current course.

In our opinion, a second needed policy element is a firm commitment to a specific national space program plan, complete with schedule milestones. Such a comprehensive statement of strategy has not yet appeared. Although we have taken no position as to the specifics of such a plan (other than those already mentioned), we have repeatedly emphasized the need for long-term commitments to add needed stability to our efforts., As I noted here last year, stability, itself, will go far toward insuring the vitality of U. S. accomplishments in space.

Mr. Chairman, we are prepared to offer more detailed commentary at a later date on current National Space Policy should such a critique be requested.

We will now review the proposed program in light of the commitments in stated National Space Policy, and our reaction to this guidance.

We have organized our remarks today into the areas of space science and applications, space research and technology, and space flight, which includes space transportation. We are pleased to see that, in each of these areas, the proposed program is consistent with avowed policy.

However, we are concerned this year, more than before, that the proposed budget falls far short of meeting the overall objective to which we have concurred: maintenance of leadership in space activities. In light of these considerations we feel it not unreasonable, in fact it is mandatory, that we advocate today a more aggressive civil space program than that which has been proposed by the Administration.

One year ago, NASA's space science program -- particularly the planetary exploration program -- was severely threatened. Your Committee and the Congress responded, showing your commitment to maintaining U.S. leadership in space exploration. We commend your support and your restoration of vital funds to the planetary research and data analysis programs.

We are also concerned by the somewhat lethargic pace of science payload development for shuttle. Twenty-nine experiments by U. S. principal investigators were selected from the original announcement of opportunity in 1978. None of these has flown. Three ultraviolet experiments have hardware development money for flight in 1985-86. The 12% increase for shuttle payloads in FY84 under Physics and Astronomy will now allow three x-ray instruments to be developed for OSS-2. But what of the rest? How can a principal investigator hold his/her team together for years waiting to be funded?

In one other very important area the Administration's budget has not reflected last year's debate. We refer to the Research and Analysis line item in the Planetary Exploration budget which has received a 10% cut in FY84. If left unchanged, this would translate into a loss of 150 of the approximately 600 research programs now funded, or <u>one out of four planetary scientists</u>. Alternatively, crucial facilities would be closed down.

In fact the research and analysis budget in a number of space science disciplines has been eroded over the last several years. Not only are young scientists being discouraged from entering these fields, but established research teams, their experience gained from a decade of space experiments, are being disbanded. We consider this a tragic loss of our nation's investment.

You have continued to recognize the value of basic research support. We believe it is consistent with your previous position to restore specifically the few million dollars to planetary research and analysis necessary to maintain a minimum viable program and to continue the upward trend established in FY 1983 in other areas of space science.

There is no doubt that our planetary exploration program, from the original Mariner 2, twenty years ago, to the spectacular Voyager flybys of Jupiter and Saturn, has been a visible symbol to the world of America's technological leadership. But the retrenchment of the U. S. planetary program in the past several years -- the lack of new starts, the cancellation of NASA's Solar Polar spacecraft, the failure to develop a mission to Comet Halley -- is viewed by the world as a signal that the U. S. is losing its technological leadership, losing its will to compete. At a recent international scientific conference, there were frequent jokes about the "tortoise and the hare," as the Soviet Union prepares two major space missions to Venus and Comet Halley in 1985-86 and successfully solicits Western European cooperation.

NASA's 1984 budget has made a good beginning in reversing that trend. However, the funding for planetary exploration remains at approximately 25% of the level a decade ago. NASA's Solar System Exploration Committee has recommended a core program for planetary exploration. The first four elements of the core program are the Venus Radar Mapper, a comet rendezvous/asteriod flyby, a Mars geochemical/climatology orbiter and a Titan probe. The American Institute of Aeronautics and Astronautics endorses the SSEC core program and recommends that NASA proceed as quickly as possible to implement the four missions listed above.

In the area of Space and Terrestrial Applications, additions made to the communications budget in FY1983 for development and demonstration of advanced space communications technology are especially noteworthy. The currently proposed course of developing and flying Ka-band (30/20 GHz) components and systems in an Advanced Communications Technology Satellite (ACTS) has our endorsement. This course should be followed using the most

cost-effective method possible. However, we strongly believe that the U.S. must continue to develop this technology now with or without commercial participation.

I want to reiterate at this point our view that the Administration's goal of moving applications programs to the private sector is sound. The immediate task is to identify and help resolve obstacles to effective and timely transition, while maintaining adequate technical support in the interim. Improperly planned actions here can have a significant adverse effect on our nation's economic, political, and military strength in the next decade. It therefore seems difficult to understand why an Administration dedicated to private-sector business development would once again propose to cut back funds for technology utilization. The AIAA's experience in our special programs involving many of the Fortune-500 non-aerospace corporations, has clearly demonstrated the usefulness of these relatively small efforts in bringing NASA-developed technology and services to the non-aerospace private sector, a function which is oriented precisely in the direction this Administration has identified to rebuild the nation's economy.

I would now like to turn to the Space Research and Technology portion of the budget. We have consistently pointed out that this is the area we consider to be the heart of NASA's and our country's future civil space capabilities. The 12% increase proposed here is a healthy sign for the future of the U. S. space effort. Technology base programs are up over 9%, and funding allocated to important space flight experiments has been increased by over 2 million dollars over FY1983. We strongly endorse these trends.

Even in light of the overall increase in this area, however, examination of the specifics of the proposed Research and Technology budget indicates that funding may not be available for many needed programs. A large portion of this funding appears to be earmarked for space station-related technology development. Although we support an evolutionary approach to a space station, we urge caution in channelling significant technology funding toward such an initiative, without a clear concept of the requirements or design constraints. Such a strategy is of special concern when it is pursued at the expense of other worthwhile opportunities.

For several years we have expressed specific concern about support for advanced liquid rocket propulsion technology. We will soon publish an Institute position paper citing specific areas of national weakness in this vital technical field. The budgetary increase in this area in FY1983 was heartening, but this year's leveling off of chemical propulsion research and technology funding may leave the U. S. in a position where it is unable to effectively produce needed advancements to capitalize on other technical opportunities or meet future requirements. As you know, many space technology advancements take years from concept inception to fruition. Perhaps none has a longer lead time or a more intense impact on system costs and capabilities than rocket propulsion. We urge continued growth in this critical field, and we are prepared to make specific technical recommendations.

The final area in which specific comment on the proposed space budget is in order is that of Space Transportation. The Space Shuttle program, an arduous technical and managerial challenge, is maturing rapidly; OV-104 will be delivered in 1984. Many obstacles to cost-effective operation remain, but the U. S. can rightly be proud of this new capability.

We also endorse steps to control STS operation costs, now being taken by NASA, which promise to improve program economies. We strongly support additional development work aimed at further reductions in launch costs.

We are, however, disappointed that a specific commitment to maintaining an orbiter production capability has not yet been made. We recognize that such a step is expensive, and that clear analytical justification for a fifth vehicle cannot be made at this time on the basis of firm user commitments. Consideration of potential commercialization of expendable launch vehicles is another factor which clouds the picture, and makes it even harder to clearly identify future STS traffic demand. However, as we noted last year, several factors lead us to believe that an investment which retains the option for an additional orbiter would be wise.

We support the strategy of acquiring spare parts in order to keep the cost of future vehicles within reach.

The Advanced Programs area of the Space Transportation budget continues to grow at a rate greater than that of the overall Agency, but in our opinion, is still desperately underfunded.

Whereas last year we advocated the urgent need for an advanced upper stage for the shuttle, we now observe that the Centaur-G and G-prime, along with the PAM IUS and other available configurations, should meet the needs we foresaw for the 1980s. Of course, they do not have the full set of characteristics needed for the long-envisioned Orbit Transfer Vehicle (OTV). To assure our nation's ability to fully use space in our interest, we still believe a more capable vehicle will be required in the longer term. Planning for this vehicle must continue now if we are to be in a position to implement this capability when it is needed.

Such a vehicle could be especially attractive if it were based in low earth orbit. A propellant depot/OTV base could be a derivative of space platforms or space stations developed in the late 1980s and early 1990s. In our opinion, such an orbital terminal, as we noted last year, will be needed to make effective use of the space shuttle, providing power and other mission-enhancing capabilities. Eventually, such a facility could provide for extended habitation without the shuttle orbiter.

We endorsed development of such an evolutionary space platform capability in last year's testimony and in our mid-year assessment of space policy. We look forward to the completion of the current NASA/DOD studies of space station requirements and architectures. These studies will help identify the proper path to achieve needed capabilities. We are concerned, however, by the absence in FY1984 of funds to continue community-wide assessment of this program, especially at the systems level. Maintenance of strong government and industry participation is essential to achieving evolutionary space capabilities, both manned and unmanned. Whatever the selected course, this teamwork should be maintained by continuing contractor systems studies.

In short, these comments reflect our view that the advanced programs element should be significantly increased.

In summary, there are six areas in which the AIAA recommends specific additions to the proposed FY1984 Administration budget.

- Shuttle science payload development
- Planetary research and analysis
- UARS flight support
- Technology utilization
- Research and technology
- Advanced Space Transportation Programs

In other areas, we also feel that a more aggressive approach is both justified and necessary.

Mr. Chairman, as you can see, the AIAA believes, after thorough and careful review, that NASA is not being adequately supported by this Administration, in light of today's needs, priorities, opportunities and constraints.

That concludes my prepared remarks. We would, of course, be happy to answer questions.

Mr. VOLKMER. Thank you very much.

At this time I will recognize the gentleman from Florida, Mr. Nelson, for questions.

Mr. NELSON. Mr. Chairman, I thank these two gentlemen for being here. I would just like your comments with regard to a letter from Budget Director David Stockman to Jim Beggs, dated June 14, 1982, in which Mr. Stockman states, and I quote:

It should not be assumed that the U.S. government should have the responsibility to fund an operational system with sufficient capability to meet non-U.S. Government needs.

He is talking about the shuttle.

Now that would be what that particular paragraph was about, the space transportation system. I will say it again:

It should not be assumed that the U.S. Government should have a responsibility to fund an operational system [i.e., the shuttle] with sufficient capability to meet non-U.S. Government needs.

Now, you two have had long experience, and I know Dr. Lovelace now sits as a private individual there, but he has been in the Government side for years. Can you help trace for me and detail for me just how much that statement of Mr. Stockman's would vary from the perceived and actual theory of the use of the shuttle as it has been developed over the past decade? Is my question clear?

Dr. LOVELACE. I think so, Mr. Nelson. I have not personally seen Mr. Stockman's letter.

Mr. NELSON. Well, I will give you a copy.

Mr. LOVELACE. I hear your quotation from it. I am not sure I am going to respond exactly to your question, and I should preface my response by saying this is obviously an issue that from AIAA's standpoint we have not in fact examined. This is a very recent event. I think I am correct that Dr. Rosen's group really had no opportunity to assess that.

Mr. NELSON. Let me just stop right here. Am I appropriately addressing this to you, Dr. Lovelace, and Dr. Rosen, since you, Dr. Lovelace, are the vice president of public policy for AIAA?

Dr. LOVELACE. That is correct.

Mr. NELSON. OK. Then let me hear your commentary without the advantage that you had heard this particular quote, and I will give you a copy of the letter. Perhaps we can follow this up in the future.

Dr. LOVELACE. Fine.

Mr. NELSON. But on the basis that you were at the very inception of the space transportation system years ago, and understood its development, I would like your commentary as to this kind of philosophical thinking emanating from the highest levels of the U.S. Government.

Mr. LOVELACE. Well, Mr. Nelson, let me give you my personal view on that subject. I have a little difficulty with some of the rationale that is used to support various positions. On the one hand, I guess we should believe at this instant that we have a fully operational shuttle system. And I am afraid that we are not yet there. We need, obviously, to continue to support that program. It is a very difficult development. And it has been a very expensive development, but one which I firmly believe is not through, nor are the benefits to whatever sector of the economy fully appreciated.

To that end I think that it is not inappropriate that the Federal Government continue its support, and it has supported the program for many years, until such time as we really have a fully operational system and we fully understand the manifold benefits that are going to flow from having that capability.

I am also sure that in that area, as in other areas of application in space, utilization of it, that the private sector will, in fact, when the risks are appropriate, step forward and provide for sharing, an appropriate sharing of the support and utilization of that capability. I do not believe personally that we are at that juncture at this instant.

Mr. NELSON. Well, does that mean that you disagree with this statement of Mr. Stockman's?

Mr. LOVELACE. I say I have some difficulty rationalizing it from my personal perspective.

Mr. NELSON. In other words, does that mean that you have difficulty agreeing with the statement?

Mr. LOVELACE. I have difficulty agreeing with Mr. Stockman's statement.

Mr. NELSON. How about you, Dr. Rosen?

Dr. ROSEN. I have had a chance to look through the notes. If I might read from our space policy statement. We assert that a goal of the national space program should in fact be, and I quote, "to achieve routine access to space through continued commitment to an operational space transportation system, sized to meet both cur-

rent and projected needs for defense, commercial, science and foreign users."

Mr. NELSON. Which means you disagree?

Dr. ROSEN. Yes, sir.

Mr. NELSON. I hear my chairman is getting tired of me saying this. I disagree, too. I will just stop right there.

Mr. VOLKMER. At this time I will recognize Mr. Bateman.

Mr. BATEMAN. Thank you, Mr. Chairman.

One of the comments that I find in the written statement is a reference to the fact that our country and NASA are not going forward with the mission to the comet Halley. Later I find references to the fact that the Soviet Union is going forward with a space mission to the comet Halley in 1985–86.

In light of the suggestion that there should be greater international cooperation in at least certain categories of planetary space missions and programs, if they are going to do it should we also be doing it, or should we take that money and do something else? Could you comment on what our posture should be in avoiding the duplication of that which others are going to do and which, hopefully, will be in appropriate scientific areas.

Dr. ROSEN. Sir, if I could clarify our statement. We don't have a position right now as to whether or not the United States should in fact pursue that specific mission. The statement was intended to illustrate a widespread perception that was created last year, which we talked to this committee about that the United States was not maintaining aggressive leadership in the planetary exploration area.

I think that message has been delivered, and I think the reaction of this committee last year illustrates that point. But we have no position about that specific mission at this point. Certainly in areas where there is effective cooperation, possibly in the scientific area, we endorse that.

Mr. BATEMAN. I take it then, that at least some of the clear recognition this committee gave it in the last session of Congress has been recognized in other agencies or branches of the Federal Government.

Dr. ROSEN. Yes, sir. Thank you, sir.

Mr. BATEMAN. I believe that is all the questions I have, Mr. Chairman.

Mr. VOLKMER. Mr. Lujan?

Mr. LUJAN. Thank you.

Dr. Rosen, did I hear your statement correctly that you think that in the opinion of your organization the Federal Government has a responsibility to continue a space transportation system for our military, civilian, and the needs of foreign nations?

Dr. ROSEN. Yes, sir, you did.

Mr. LUJAN. Forever?

Dr. ROSEN. I didn't use the word "forever." We recognize, as Dr. Lovelace said, that this business of space transportation is a fast changing world. We are trying to move more of our services onto the space shuttle in accordance with national policy. We recognize the potential of commercialization of space transportation in the private sector. We recognize that the Europeans have a launch ve-

hicle. It is a fast evolving world. So we didn't intend to mean that this policy would be one that would last forever.

Dr. LOVELACE. I think, Mr. Lujan, that the Government has to date provided service to the commercial sector in the form of launches of commercial payloads. The private sector has paid for that service. At least my last reckoning, there was neither a profit nor a loss in that business. And the reasons for that, in the early days of any launch system capability is one of high technical complexity and risk. It seemed prudent that the developers who understand the most about that system conduct those launches and that the private sector pay for those services when they utilized them. And I think the same will be true for some period of time on the shuttle.

We may be at a juncture on the expendable launch vehicle where in fact that could be commercialized. That is a decision that has not yet been made or implemented. But we seem in my judgment not to be in that position yet on the shuttle.

Mr. LUJAN. Well, I agree with you. But don't you envision at some point with a space station out there and various companies producing medicines, materials, and those kinds of things, that flight to that station would be turned over to a TWA, Pan American, American, Eastern Airlines kind of operation? If the Government needs to get up there for some reason, and we would still maintain a separate station probably for military purposes, we pay for it; just as if Jim Beggs wants to go to San Diego he can climb on TWA and go over there? Don't you envision that at some time?

Dr. LOVELACE. I certainly do. And the situation even today is that if you want to place a communication satellite in orbit, you pay for that service. When I flew here from St. Louis this morning, I bought a seat, not an airplane. And it is possible, very possible that at some point in the future that it will evolve to that level of commercialization and facility for utilization of this national capability. And at that point, which as I say I don't think we are there yet, you can then talk about who should be the operator.

Mr. LUJAN. Put it up for bids?

Dr. LOVELACE. Yes, sir.

Mr. LUJAN. The reason that I bring that up is because I sense a very strong reluctance all the time with all witnesses, with just about all of the proponents of the space program, to let go; that is our baby and we are going to hold on to it forever. I was looking at those questions and answers that Dr. Chartrand was talking about earlier today. The very, very low numbers were those where mother ought to let go of her program. NASA should be abolished and let the private sector take over all civilian space activities. It was only 1.9 on a scale of 1 to 10.

But Congress should change NASA's charter to allow it to add operations to its R&D role. That is 7.1 on the scale of 1 to 10. There seems to be that strong reluctance, as I say, to letting go of your child, just keep it within NASA. That bothers me because the Government is that way very much.

Dr. LOVELACE. Well, I think, Mr. Lujan, that there is always that human reaction to letting go of a program, a development which has been very complex and has consumed a great deal of the time and talent of an institution, or in the case of the shuttle many in-

stitutions, both private and public. And I think that is a natural reaction. My reaction, though, is also one of you can pull that baby away before it is properly weaned and then the consequences of it can be very severe. And I just worry, it is a very difficult thing to technically judge, but I would have to say personally that I think we are not there yet on the space shuttle program.

Mr. LUJAN. I agree with you on that.

Dr. LOVELACE. But I am not saying that there cannot be a time and a point at which that is in fact a prudent thing to consider.

Dr. ROSEN. Mr. Lujan, I apologize for reading to you today, but representing over 60,000 people I feel I can best work from a statement to which they have mostly agreed. As to your statement that most of the advocates of the space program have resisted this tendency, let me cite from our public policy statement in which we ask that the Federal Government should "encourage by cooperation and appropriate incentives entrepreneurial investment by the private sector in high risk, high payoff applied research and development and the applications of space systems technology to the commercial marketplace."

We feel that handoff is, when done appropriately, the right thing to do.

Mr. LUJAN. You are talking about the Johnson & Johnson?

Dr. ROSEN. As an example, and also any kind of development that turns into a commercial operation, such as transportation.

Mr. LUJAN. OK. The space station, or whatever it ever gets to: You stated that it is moving along too slow. My understanding is that NASA is just going now, or maybe has gone, to industry, and to various agencies to ask what the needs might be for a space station that may influence its design: Perhaps they couldn't move any faster than they are if they don't have all of that information.

Dr. LOVELACE. This is a subject that I will ask Dr. Rosen to comment on that this group looked at. And, Stan, why don't you comment on that first?

Dr. ROSEN. I have two specific points. First AIAA has endorsed a commitment to the evolutionary development of such a facility which could in the long run include permanent habitation. It is that commitment we haven't seen. We are not arguing with the pace of the ongoing program.

The second point we made in the proposed course for fiscal year 1984 is that we are concerned that money seem to be available for continuing contractor involvement at the systems level to maintain industry-government teamwork. As we go into the development program most of that work is being brought in-house to NASA. That is of concern to AIAA. But in neither of those two statements do we challenge the pace of the program.

Mr. LUJAN. NASA has told us they have brought all of that in-house because of criticism from their own people that they were not getting enough hands on experience, that too much of it was being contracted out. And so they felt that, with all their training and education, they were really only shuffling papers and were not getting enough experience. That is the reason, they say, that they brought in this work in-house.

Dr. ROSEN. There is a balance there somewhere and we are all trying to find it.

Mr. VOLKMER. Thank you.

Mr. Chandler.

Mr. CHANDLER. Thank you. I would like to follow up. Mr. Nelson read you the statement by Mr. Stockman in which, as I understand the statement, Mr. Stockman was saying as soon as the space program is operational, which seems to be the key word, then it ought to be paid for by the private sector. I think I understood you to say you disagree. Then in response to questions by Mr. Lujan and Mr. Bateman, you have essentially said that as soon as it can be a private venture you think it ought to be. I am a little confused as to what your position is with regard to Mr. Stockman's statement.

Dr. ROSEN. Sir, first of all I didn't read the statement of Mr. Stockman, either, but, I didn't hear Mr. Nelson exactly the same way you did. What I thought he was talking about in quoting Mr. Stockman was the sizing of the shuttle fleet. Whether or not it should be sized to meet commercial as well as Government demand, not whether the fleet itself should be commercialized.

Our position on commercialization where appropriate, does not necessarily address the shuttle. As Dr. Lovelace said earlier, if it were appropriate, we would endorse commercialization of the shuttle in part or in total. We don't have a clear enough perspective to see whether that is the right idea. We are simply endorsing the principle of commercialization where appropriate.

Dr. LOVELACE. Let me just amplify. The second point is that it seems to me that we should have the capability in the United States in the shuttle fleet, with its unique capabilities, sufficient to meet our projected commercial, military, and scientific requirements. As in the case of expendable launch vehicles, when those services are rendered the benefactor in the private sector should pay for them. But the worrisome thing is that we will not have the capability. It simply will not be available even if you were willing to pay for those launch services on the shuttle. And that is the part that I disagree with.

Mr. CHANDLER. Thank you, Mr. Chairman.

Mr. VOLKMER. Thank you.

Mr. Brown?

Mr. BROWN. Gentlemen, I would like to explore a little bit, it may be redundant, your thinking about the space station, or platform program. You have presented the general situation for the 1984 budget. The NASA is drawing in-house basic studies and terminating the contractor involvement. In-house studies are about the level of $15 million, as I recall. The commitment or the statement is made in the budget that we are planning to deploy a system in the 1990's. I don't know whether that means actually fly it or begin to build it, but it contemplates some higher level of activity in the 1990's.

I believe, personally, that there is support for a schedule that would move us a little bit faster, although I am not thinking in terms of anything all that dramatic. I think the pacing factor is going to be the degree to which there is public understanding and support of the importance of such a deployment as a key part of our next generation of space activities. This is one reason I favor contractor involvement, because I think that tends to build up a

concept within industry of the potential that we have that is very helpful.

Have I lost you at this point? Are we in general agreement?

Dr. LOVELACE. Yes, sir.

Mr. BROWN. The next step that I think might be important is going beyond just contractor involvement and developing some public excitement about this concept outside of that rather esoteric group that is generally made up of space nuts, like you guys are—and there is potentially a very large group of such people. What I would be interested in knowing is, do you feel that there is any role for your organization, which is I guess, the closest thing we have to a mass organization concerned with space, in looking at this project from the standpoint of its contributions to American leadership, personal welfare, and the stimulation of a more widespread form of public discussion?

Basically the Congress is going to respond to public awareness in this area, more than other areas it seems to me. I am interested in knowing if we can generate that.

Dr. ROSEN. If I could follow your logic, I agree with what you have said. If such a program were to be established, it would be important to have the contractor support as well as eventually the public support. But before addressing that question I think the most important support needs to come from the uses of such a facility: that community, or those communities, which would in fact either have to put money into developing or using that facility. And that is the thrust of the current level of studies, to really understand from the scientific, from the applications, from the national security points of view what that capability would do.

That is a step which I think you jumped over, but I think is probably the most important step at this point in time because without that support I think it would be useless to try to convince the American public it is a good idea.

Mr. BROWN. I might have jumped over it but I am not unaware of the importance of it. What you are describing as user studies are what could be more generally described as market studies; absolutely essential I think. This establishes whether or not this is just something exciting and nice or whether it is something very practical and useful to the human society. But there always has to be a little exploratory analysis of this sort of thing. People have got to come out with fairly far-fetched ideas and then begin to make them more practical, refine them.

Can you enlighten me as to the nature of the contractor studies? User studies, if that is what they were? Were they aimed at establishing some of these points that you are suggesting?

Dr. ROSEN. Sir, it would probably be better to ask NASA that question, because they manage that effort. But that was generally my impression, that it was their intent to get the contractor community talking to the user community, first, to educate each other about possibilities and requirements, and second, to evolve out of that the kind of architectural arrangement which would lead to a reasonable program plan to get some kind of facility developed. So, yes, that was the intent of the studies.

Mr. BROWN. I am trying to extract from this some general principle—I have mentioned this before—in which we can base policy al-

ternatives. What we are doing here is not something new, or unique. It is something sovereigns have been doing for several hundred years. I am sure when the King of England started giving charters away to the New World he wanted contractor studies as to how much the fur trade was going to bring in, something like that. When the U.S. Government started giving away public land for farming and building railroads on, I am sure they did a little speculation as to what this was going to contribute to the general welfare. So it is not exactly a new process.

But we don't seem to understand the generality of it and its contributions when we are opening up any new frontier to potential public welfare in the future. We look on each new effort as sort of an absolutely unique thing that governments have never done before, and we are sort of pioneering when actually we are merely following a principle as old as governments are and trying to serve the public welfare by opening up new opportunities and new frontiers.

Well, the basic question that I am really trying to get at is, if we wanted to move this thing ahead a little faster, we can put more money into the budget. We can also take steps to try and build more public support. Both, probably, are going to be necessary.

Dr. ROSEN. If I may, sir, the AIAA is probably not as well qualified as an organization such as the National Space Institute to address public support directly, and I just want to reiterate that. It is our role, I feel, as professionals, to make sure that the grounds for such a program are well established before anybody turns to the public and tries to create castles in the sky. And I am not saying any of these programs are castles in the sky. I am saying as professionals we owe that to the country. That is what we are trying to do now, to make sure we understand what a program would look like, and why it would be done. It is in that light that we have endorsed, not only for a space station but for the entire civil space program, a long-range program plan which would consolidate where we think we are going in the civil space program and make it visible, both to the community which has to justify it and to the public, which has to pay for it.

Mr. BROWN. Well, I am reminded that when Queen Isabella sent Columbus over here she had a completely wrong idea what the resources were going to be.

Thank you.

Mr. VOLKMER. I would like to continue on that a minute, on the specific national space program plan.

What would be some of the specific goals that you would like to see in such a plan?

Dr. LOVELACE. Well, Mr. Chairman, we have been considering the possibilities from the perspective that Dr. Rosen just pointed out. We may be space nuts but we are pretty well seasoned and pragmatic about it, because of our experience and our education. Dr. Rosen can speak to it briefly, because it can get to be a fairly lengthy presentation when one attempts to systematically go through and look at the options. I am not sure that we are necessarily the group that should prioritize these options, but rather to assist in the process, which is not unrelated to the point that Mr. Brown was pursuing a moment ago, of insuring that that full

public support is available. By sifting through the options, there certainly will come perceptions of the utility of space stations or a permanent presence of man in space, as well as other capabilities even beyond that.

Stan, I don't know whether you want to comment any further on that right now.

Dr. ROSEN. Well, sir, just to say, as Dr. Lovelace mentioned earlier in his formal statement, we have not endorsed any specific milestones or goals along that road. However, we have been working with the Congressional Space Caucus to present that group with at least a menu, laid out over the next 20 years, of where we might go in civil space programs in the four areas of science and exploration, programs aimed at providing new services for humanity, programs aimed at providing new products for use on Earth, and programs aimed at developing a capability to support these activities.

And as Dr. Lovelace said, we don't know all the answers to that, but we have tried at least to explore what the possibilities are.

Mr. VOLKMER. Now, if the Congress would restore the funds in the 1984 budget for planetary exploration research and analysis, what do you anticipate that money would be used for?

Dr. LOVELACE. Let me see if I can respond to that question, Mr. Chairman.

I don't think that we know in specific detail about this particular area of science or that particular area of science. In fact, I am not sure that the groups that supported Dr. Rosen's assessment went to that level of detail. But I think the general feeling was that there needed to be an increased underlying support for that science base to analyze the data and results from some of the missions that have already been funded, and to insure that we keep together a scientific community. That community is not large now, but I think it should be supported in order to think through future mission possibilities. And in fact, that is the group of people that should help prioritize the specifics of future expenditures.

It seems to us—I will let Stan correct me since I was not present in many of the discussions that they held—that in examining the budget there seemed to be insufficient support of that activity in relation to other activities.

Dr. ROSEN. Our specific concern is the proposed reduction in that line. Where that money would then go or come from remains to be seen. What facilities NASA would close or what lines they would stop studying we don't know. But whatever that answer is, that is what we would propose not be cut. In other words, we are not asking for an addition in this line, just to eliminate the reduction.

Mr. VOLKMER. And basically it is to be able to continue to analyze the data that are coming back so we don't have to break up those teams that are there.

Dr. LOVELACE. It is both analyzing data from missions as well as projecting ourselves, in a scientific vein, into the understanding of our solar system and our universe.

Mr. VOLKMER. As I understand it, you correct me if I am wrong, that AIAA is on record in favor of the fifth orbiter. Is that correct?

Dr. ROSEN. If you mean by record that we did at this time last year, on the basis of an assessment of traffic models and on the

basis of studies done a few years ago by AIAA, for OSTP, endorse buying the fifth orbiter, our position this year has changed. We are not endorsing a commitment to procure a fifth orbiter now, but rather to maintain the capability to get that orbiter in the future at a reasonable cost, so that we don't preclude that option.

We feel several factors would in fact, or could in fact in the future lead to a very clear need for additional orbiter service.

Mr. VOLKMER. Has AIAA ever been involved in NASA's technology utilization program to any extent?

Dr. LOVELACE. Yes, Mr. Chairman, we have been in a small way. I would say we have tried to support the technology utilization and transfer activities of NASA; that is to say the transfer of technology and capability to the U.S. private sector. We have addressed this subject in a little more detail in our complete statement. Maybe Dr. Rosen would like to elaborate further on that. I think it is an important activity.

Dr. ROSEN. This is another area where I can't resist getting something on the record. AIAA does have a small contract from NASA in this area. We have brought more than 500 nonaerospace R&D executives from over 170 of the Fortune 500 companies face to face with NASA specialists, in a wide variety of subjects, so they can understand the technology that has been developed in the NASA and try to use it.

I would like to take a few minutes to read one executive's comments. This is not an atypical comment. This was Gordon Millar, vice president of engineering of Deere Co., that makes farm machinery, and as a result of 13 briefings with NASA and AIAA and with John Deere over the past 3 years he made the following statement:

> We at Deere have new technology needs that couldn't be met internally and we well realize if we are going to be competitive in the global market we have to incorporate the newest technologies. This program"—referring to the program that AIAA runs in the TU line—"This program made us realize that NASA is the finest technological resource in the world bar none. I simply cannot find that technological depth and scientific capability anywhere. We have built one-on-one relations with Deere and NASA specialists in many technological areas over the past three years.

He goes on to explain what some of those were. I guess you will agree we feel pretty strongly that this is an important although a small part of the NASA budget.

Mr. VOLKMER. I assume you would support at least continuing funding of that program.

Dr. ROSEN. At previous levels.

Mr. VOLKMER. I have no further questions. Anybody else have any questions?

I want to thank both of you for being here and giving your testimony today.

Mr. VOLKMER. The committee will now proceed with testimony from our final witness, John W. Robinson of the Aerospace Division, American Society of Mechanical Engineers, who is accompanied by Phillip J. Legendre.

[A biographical sketch of Mr. Robinson and Mr. Legendre follows:]

JOHN W. ROBINSON

John Robinson has worked in the Aerospace Industry for twenty-four years. He has been very active in professional society technical affairs for several years including executive leadership at the national level. He is a Fellow in the Institute for Advancement of Engineering, current Chairman of the Aerospace Division of ASME and Vice-Chairman, Federal Government Relations, Government Relations Operating Board. Previous professional society positions include Chairman, AIAA Orange County Section; President of the Orange County Engineering Council; National Chairman of the ASME Propulsion Technical Committee; and Technical Program Chairman for the AIAA/ASME/SAE Joint Propulsion Conference.

John's twenty-four years of collective experience in the engineering and management fields has been primarily in Propulsion Systems. He has worked over the years for three major Aerospace Companies and the University of Colorado Engineering Experimental Station.

PHILLIP J. LEGENDRE

Organization: Eastern Technical Division, Washington, D.C.

Position: Member of the Technical Staff, Technology Applications Directorate.

Industry Experience: (26 years).

Mr. Legendre was recently assigned to the U.S. Senate Subcommittee on Science, Technology, and Space through an Aerospace Advanced Study Grant and an ASME Congressional Fellowship. Primary assignments included the NASA Authorization Act with emphasis on the aeronautics tasks, the Landsat System and associated congressional policy and pending legislation, the UNISPACE 1982 Conference, the Space Processing Contract planning in the Senate, the future U.S. space policy as envisioned by the Subcommittee, and the future emphasis for U.S. aeronautics programs.

Previous experience at Aerospace involved technical support to the thermal energy storage system (TES) programs sponsored by the Office of Advanced Conservation Technologieis (ACT), Department of Energy (DOE). Assignments included a marketing analysis for aquifier thermal energy storage, an environmental assessment for industrial waste heat thermal energy storage, preparation of a Procedures Manual for ACT, a review of the Multiyear Program for TES as applied to solar thermal energy storage, preparation of a paper summarizing the TES programs, and a technical review of the economics of heat storage in alloy transformations as applied to TES. Mr. Legendre was also involved in a special California-based project, where he was responsible for the production of flight-acceptable, carbon-carbon exit cones for the IUS Program.

While assigned to the Aerospace California Office, Mr. Legendre's assignments included 8 years as a project engineer to more than 25 programs and tasks involving the development and application of nosetip and heatshield concepts and instrumentation for reentry vehicles. For 9 years as a member of the technical staff, he provided technical support to reentry vehicle programs in the areas of feasibility studies; internal system heat transfer analyses and tests; heatshield and instrumentation evaluation; and preparation of the environmental specifications, preflight test planning, and postflight data evaluation and correlation.

Prior to joining Aerospace, Mr. Legendre was involved for 3 years in the following positions and areas of responsibility concerning the general area of systems engineering:

Senior engineer charged with conducting a study to determine the feasibility of the employer to initiate a life support system program and as the coordinator on the F4C antiskid system.

System analyst and control engineer assigned to the synthesis and analysis of overall system concepts for submarine applications; nuclear submarine turbine overspeed control system analysis; missile hydraulic control system analysis; and heat transfer and thermodynamics analyses for the hydraulic control systems of various missiles, tanks, and submarines.

Mr. Legendre was employed initially as a nuclear engineer for 2 years. His assignments included:

Determining the fast and thermal neutron flux distributions and the gamma heat generation in the radiation shields of the Hallam Nuclear Power Plant and of the Sodium Reactor Experiment using digital computer techniques.

Studying radial power flattening in organic cooled reactor cores.

Studying the reduction of radionuclide concentration in organic reactor coolants and of radiological hazards pertaining to organic reactors in maritime applications.

Determining the dose rates to fast neutron scattering in the inner bottom and the formulation of a system block diagram of the leveling control to a nuclear reactor steam generator for the nuclear-powered-cruiser U.S.S. *Long Beach*.

In parallel to his Aerospace employment, Mr. Legendre has lectured in thermodynamics at several schools including the University of Southern California, and he has lectured in technical seminars across the country on Energy Control and Management Systems.

Education: Engineer in Mechanical Engineering, 1974, University of Southern California; Master of Science in Nuclear Engineering, 1958, University of California at Berkeley; Bachelor of Science in Mechanical Engineering, 1957, University of California at Berkeley.

Awards/Professional Affiliations:

Maryland Registered Professional Engineer in Mechanical Engineering, 1983.

Recipient of an ASME Congressional Fellowship, 1982.

California Registered Professional Engineer in Control Engineering, 1979.

Corecipient of the Dr. Charles Stark Draper Award for the most outstanding Tutorial-Lecture presented at the 24th ISA International Instrumentation Symposium, May 1978.

Elected as Fellow into the Institute for the Advancement of Engineering.

Recipient of a Certificate of Award by the ASME Council for services performed as Chairman, Los Angeles Section, 1978–1979.

Recipient of a Certificate of Award by the ASME Council for services performed as the cofounder and first chairman of the California Inland Empire Group of the Los Angeles Section.

Elected to Pi Tau Sigma, University of California at Berkeley, 1957.

American Society of Mechanical Engineers; seven positions of responsibility held to date.

Instrumentation Society of America; six positions of responsibility held to date.

United States Naval Institute.

American Institute of Aeronautics and Astronautics.

Institute for the Advancement of Engineering.

STATEMENT OF JOHN W. ROBINSON, CHAIRMAN, AEROSPACE DIVISION, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME), ACCOMPANIED BY PHILLIP J. LEGENDRE, MEMBER AND FORMER CONGRESSIONAL FELLOW, ASME

Mr. ROBINSON. Thank you, Mr. Chairman, for the opportunity to comment on the NASA fiscal 1984 budget. I am John Robinson, chairman of the Aerospace Division for ASME, and I am here speaking today for Dr. Serge Gratch, who is president of ASME. He was unable to attend. I have with me Phillip J. Legendre a previous congressional fellow from ASME.

I would like to submit a prepared statement for the record and provide summary remarks.

ASME represents about 107,000 members with a broad technical interest. We have roughly 20,000 members that are involved in aerospace activities or involved in technology transfer. We are proud of NASA's performance in space, and we are honored to support the NASA budget process in these times of tightly constrained budgets.

In general, we are pleased with the funding for fiscal year 1984 in the proposed NASA budget, and we are particularly pleased with the new program starts in the Venus radar mapper mission, the tethered satellite system, and the basic technology involved in the space flight experiments.

I would like to summarize some constructive suggestions concerning the NASA program matters. First I would like to address the overriding importance of a definitized national space policy. One of the greater achievements of the United States in modern times has been the establishment of our position of leadership in

space technology. Every cent spent on space is spent right here in the United States creating jobs and stimulating the U.S. economy.

Further, the return on the investment far exceeds the dollars spent in the space program and benefits every aspect of our national economy from agriculture to communications and from manufacturing to medicine.

We cannot risk losing our position of technological leadership in space in order to achieve some short-term economies. The President outlined his basic U.S. goals during the STS–4 landing at Edwards on July 4. But he left unstated the basic direction the people, the companies, the universities, and the agencies require to work on aggressively and confidently in the future.

Participants need to know as specifically as possible what the country plans to do. In this environment of constrained budgets we must plan to maximize our output and minimize work in favor of greater productivity and program accomplishments. In past years, we have seen a number of stops by NASA of space programs such as the Venus radar mapper which was the Venus orbiter imaging radar, the solar maximum mission, and also the inertial upper stage. Stop-and-go programs are very costly to the Nation. They introduce inefficiencies in contractor performance, interruptions and uncertainties, creating adverse effects on the ability of NASA, the universities, and industry to conduct orderly and timely business.

We feel that our No. 1 resource in the country is our people and our technical capability. Skilled personnel are lost to other activities when programs suffer stops, restarts or extensions due to budget restrictions. If we are lucky we bring them back onboard. Generally, we are faced with a learning curve that adds cost, and the fact that we are actively discouraging our new generations from entering the aereospace field.

The space program has been active now for 25 years. Many of the high technical people are close to retirement. We need to get the young people involved so they can carry on the activities in space development.

We feel we need a stable, longterm national space policy with specific goals and timetables that all participants, including our upcoming generation, can understand, work for, and look up to as a meaningful goal and commitment.

NASA has demonstrated superior capabilities over the past 25 years in space, including the shuttle now nearing operational status. In previous programs roles have been traditionally clear, decisive, and effective. However, there have been no plans to phase some of the NASA element out and phase private industry in. This is needed today in some areas for economic and foreign competitive reasons.

We commend Congressman George Brown's effort toward legislating an enduring, bipartisan, definitive national space policy and feel it is overdue and essential. It is time to rethink the entire national space policy issue and consider provisions for privatization of select and mature space-related technologies, provide for continued R&D by NASA of advanced space technology in all areas, and provide for controlled dissemination of advanced technology data into the private U.S. industry, to prevent and maintain the competitive edge over foreign enterprise.

Having discussed the overriding importance of definitive policy, I would like now to summarize constructive suggestions we have concerning the NASA program. In the upper stage development area, we believe an advanced satellite ferrying and retrievable spacecraft should be developed to allow selective retrieval, repair, and reuse of high-cost satellites.

Relative to commercialization of space programs, we believe strongly that a major space project with commercial promise can and should be gradually turned over to private industry. We include the Landsat system, expendable launch vehicles and the shuttle processing contract. We also see commercialization of expendable launch vehicles as supporting a competitive role for the United States in view of the potential world competition. ELV's do not compete with the shuttle.

As far as the fifth orbiter, we feel strongly the manufacturer of the fifth orbiter should proceed. If necessary, we believe the Congress should encourage a private industry group to purchase the fifth orbiter. We believe this orbiter as well as the alternate launch pad at Kennedy Space Center should proceed as soon as possible to assure early space transportation system commercial operational capability.

Relative to advanced R&D, we believe NASA should continue R&D in all technology areas, particularly in the advanced communication and technology satellites.

We believe technology transfer and utilization activities should be restored. Technical development under NASA programs should be exploited to help modernize old industries and establish new high-technology industries within this country.

We feel a permanent manned space station program should be a cornerstone of the national space policy. We need to be able to consolidate our activities in space in the future.

To summarize, there has to be a better way of letting the Nation know what is going on and where the country is headed in space. We need a team involving industry, universities, and Government. Our foreign friends and enemies each have a team. The clock is running. We must work together in addressing the competitive challenge facing our Nation today.

We believe it is time to privatize many major efforts under NASA jurisdiction where commercial promise exists—and commercialize by U.S. industry, not foreign enterprise. We do encourage meaningful international cooperation in space. We think NASA should continue doing R&D that they do well.

In the future we believe a need exists to control our advanced R&D results in manufacturing methods such as advanced composite technology. This will be the heart of our advanced manufacturing projects in the near future.

We must not get caught off base by thinking we have done all we can do in specific technology areas, just because no immediate return is perceived. Time shows that technology leapfrogs itself. Propulsion technology is a good example. We have cut back, as previously stated, and need to restore technology development in this area. We think NASA is doing a good job in space. We need to continue maintaining that posture in the future.

Thank you for the opportunity to speak today, and Mr. Legendre and myself will be pleased to answer questions for you.

[The prepared statement of Mr. Gratch, Mr. Robinson, and Mr. Legendre follow:]

The American Society of Mechanical Engineers

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Comments on

The FY-1984 NASA Authorization Request

Before the
Subcommittee on Space Science and Applications,
Committee on Science and Technology
U.S. House of Representitives
March 3, 1983

Dr. Serge Gratch, President
The American Society of Mechanical Engineers

Mr. John W. Robinson, Chairman,
Aerospace Division
The American Society of Mechanical Engineers

Mr. Phillip J. Legendre,
Member and Former Congressional Fellow
The American Society of Mechanical Engineers

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INTRODUCTION

I am Serge Gratch, President of the American Society of Mechanical Engineers (ASME), an educational, scientific and charitable society founded over 100 years ago with a membership exceeding 100,000 mechanical engineers. Because of the variety of applications of mechanical engineering approximately 20 percent of our membership is involved in the aerospace industry and space sciences. Traditionally, we offer comments on technical problems, but are pleased today to respond to a request to comment on programmatic aspects of the NASA FY-84 budget.

We are honored to support the NASA budget process in these times of tightly constrained budgets and hope that our comments, now and in the future, will be of value to this Subcommittee. We believe that as working engineers and developers of future engineers we understand the need to support and develop space technologies through dedication to high quality engineering.

In general we are pleased to see the funding increases in the proposed NASA budget, most particularly, we are pleased with the several new program starts. In the remarks that follow we have constructive suggestions to make on some of the NASA space programs. Before discussing these specific programs, however, we would like to address the overriding importance of a National Space Policy.

NATIONAL SPACE POLICY

One of the greatest achievements of the United States in modern time has been the establishment of a position of leadership in space technology. Our achievements in this field have many valuable consequences that are well known to this Subcommittee: Our quality of life has been substantially improved directly and indirectly through effective technology transfer; the quality of all science has been improved; finally and very importantly, our space program continues to contribute greatly to our defense systems and national security.

These fantastic advances and contributions to our national well being have been possible because of a great national commitment that evolved from the dedication of NASA, the effected branches of the Defense Department and the ingenuity of our engineers and scientists. Underlying all of these advances there is a clear inference of a national policy; however, there are indications that this national policy is not well understood, and is not uniformly adhered to.

Without a well understood and supported policy, economic and political pressures may, in some cases, cause some to think that we should "spend our money in the U.S. and not in space", but this is short-sighted, falacious thinking. The foundation for much of today's economic viability was born from the support of our space programs. Space programs benefit every aspect of our national economy, from agriculture to communications, from manufacturing to medicine.

We cannot risk losing our position of technological leadership in this critical area in order to achieve some short term economies.

We believe the U.S. should have a definitive National Space Policy. The President outlined basic U.S. goals at the July 4th, 1982 Shuttle landing but left unstated the basic direction the people, the companies, the universities, and the agencies require to work agressively and confidently on the task. A strong space program is no different than any other program: the participants need to know, as specifically as possible, what the country plans to do.

In past years we have seen a number of NASA "stop-and-go" space programs. Included are the Venus Radar Mapper (formerly, the Venus Orbiting Imaging Radar), the Solar Maximum Mission, the Inertial Upper Stage (IUS) and the International Solar Polar Mission (ISPM) to name a few. Stop-and-go program activity makes it difficult for U.S. Space contractors to conduct their business in an orderly fashion. With each cancellation a program team breaks up. It is expensive to reassemble teams for restarts. Sometimes the restart teams are not equal to the original teams and a technological edge is lost. This is not a plea to continue programs that no longer satisfy our goals; rather, it is a plea for more clearly defined and supported goals.

Universities are also vulnerable to stop-and-go programs. When a program is cancelled, the assigned graduate students leave to work in other programs or get discouraged and depart the university altogether. If there was an adequate supply of talented indivijuals to go around, perhaps the problem would be less serious. Unfortunately for stop-and-go programs, however, the best and the brightest persons have many choices. Program uncertainties discourage these essential contributors to one of the country's most challenging and economically stimulating programs.

NASA demonstrated superior capabilities in the Mercury, Gemini and Apollo programs. In these (and other) programs their role was clear, decisive and effective, but even with Apollo, there was no plan to phase some of the NASA elements out and phase in private enterprise. A plan that identifies the roles for all participants with a focus on future private sector use of the technology is essential if we are to proceed without interruption. Delays that occur when there is no such plan allow foreign competition to catch up.

The kind of commitment that resulted from President Kennedy's pledge to "put an American on the moon..." is more economical in the long run than giving in to short term pressures.

We commend Congressman George Brown's efforts toward legislating an enduring, bipartisan, definitive National Space Policy. We need a policy with goals and programs to seize the "New Frontier" for mankind in areas such as space manufacturing and advanced communications. Without goals, money and talent run a great risk of being misdirected; without programs, goals tend to become meaningless.

Having discussed the overriding importance of a definitive Policy, we would like now to address specific NASA programs.

UPPER STAGE DEVELOPMENT

During the past year there was considerable controversy concerning an upper-stage to carry payloads from the low orbit space shuttle to geosynchronous orbits. Until last year, the Inertial Upper Stage (IUS) was being developed for this mission. When the payload weight requirements increased to 10,000 lb. a new upper-stage became necessary. The candidate selected by the Congress for this new mission was a reconfigured Centaur. Ultimately, an even more versatile vehicle and perhaps a manned one at that, will be required to ferry satellites, etc. from low earth orbit to geosynchronous orbit and back with stops in between. Considering the very high costs of current and future satellites, we recommend that advanced satellite ferrying and retrieval systems be included as a specific program objective in our National Space Policy. The savings in retrieved and repaired satellites should pay for the program.

VENUS MAPPING MISSION

Because of the many similarities between Venus and Earth, the great differences are all the more obvious and can provide unique insights into the Earth's workings such as earthquakes, volcanism, climate and life. By identifying geologic processes on Venus, we will better understand the Earth. Being the first in a series of low cost planetary missions, Venus Radar Mapper assumes importance beyond its scientific value. It is the model on which future missions will be judged. It is a worthy model, consisting of well-defined objectives, innovative design, proven technology and mature leadership. We would like to add our endorsement of the Venus Radar Mapper to that of the Space Science Board of the National Academy of Sciences, the Committee on Planetary Exploration, the Solar System Exploration Committee and others.

SPACE SHUTTLE LAUNCH OPERATIONS

The current space shuttle turn around operations are very expensive. The various NASA centers require high level multi-management concurrence on almost every decision dealing with the process. Thus the proposed NASA Shuttle Processing Contract (SPC) which reduces the number of shuttle processing contractors from scores to a few holds great promise for increasing shuttle turn around efficiency and lowering cost. We enthusiastically endorse the SPC and would, of course, like to see at least some of the personnel and monies saved allocated to the basic research programs which have been reduced during the past decade to to help finance the shuttle program.

PRIVATIZATION OF EXPENDABLE LAUNCH VEHICLES

NASA currently provides launch services for private companies on expendable launch vehicles (ELVs) as well as on the shuttle. In addition, several U.S. companies are attempting to develop ELV commercial services. We believe that the time has come to turn the ELV segment of NASA launch services over to private industry completely. This would free additional NASA personnel positions and monies for research and development missions.

LAND REMOTE SENSING SATELLITE SYSTEMS

As the NASA Administrator, Mr. Beggs, noted in his opening remarks when he presented the Administration's budget to the full Committee last month, the new land remote sensing satellite, Landsat 4, is in orbit and is producing superior images with its new thematic mapper. In spite of this good news, we are concerned with the future of Land Remote Sensing Satellite Systems.

During the past two session of Congress, members were unsuccessful in defining a future for Landsat, either private or federal. During the past year, the Administration's cabinet council studying the future of Landsat decided "not to decide". The future of Landsat was delegated to a special commission formed by the Secretary of Commerce. In late 1982, the commission made recommendations to Secretary Baldridge on the program's future. As it stands now, after the launch of the Landsat D-prime satellite, NASA's role ends and the National Oceanic and Atmospheric Administration (NOAA) will operate the Landsat systems until 1988, the projected life expectancy date of the D-prime vehicle. In the meantime other countries, notably France, are developing competing systems because they apparently believe that the U.S will not continue the orderly development, deployment and data processing of land remote sensing satellites after 1988.

We therefore recommend that Congress encourage NASA to privatize the Landsat system, in whole or in part, as it becomes economically feasible to do so. We also recommend that NASA be instructed to continue the orderly development of land remote sensing technology with their superior Landsat engineering and scientific team. Failure by Congress to properly provide for the Landsat Program may result in another U.S. world-leading technology being lost to overseas competitors.

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITES

When the Comsat Corporation was founded in the early 1960's the U.S. privatized satellite communications. Although private industry has worked marvels expanding the applications of communications satellites, they have not, unfortunately, pursued the necessary research and development of communiciations satellites required to keep the U.S. technologically in the lead. Japan for example, has started developing the 20-30 GHZ communications system which was dropped from the NASA budget in favor of private initiatives.

We strongly endorse the new Advance Communications Technology Satellite (ACTS) project. We recommend that NASA maintain its advanced technology communication satellite team and continue to provide the country with advanced communications satellite development. We further recommend that the technology output from these programs receive early domestic distribution so that U.S. industry has the opportunity to acquire and maintain a longer-term, technological lead over foreign competitors.

TECHNOLOGY TRANSFER/TECHNOLOGY UTILIZATION

Because of the vast sums of monies expended over the years by NASA to develop the new space technologies, Congress mandated technology-transfer in order to spread the new technology throughout the U.S. Unfortunately, we note that the FY-1984 Technology Utilization line item has been cut to a fraction of its FY-1983 level. We recommend that the Technology Utilization appropriation be restored to its FY-1983 level in order to provide the impetus to form new industies and update older ones.

We recognize that the NASA Technology Utilization funds are insufficient to finance the new industries or the retraining of the formerly skilled unemployed. Therefore we strongly support (other) Congressional initiatives intended to provide for the training of the technicians required for the new high-technology industries evolving from the NASA high-technology programs.

It is the exploitation of the new technology which will enable the U.S. to regain its position in the world marketplace. Without the exploitation of new technolgies, the U.S. will have great difficulty in its efforts to recover its former industrial greatness.

FIFTH ORBITER

The current flight schedule for the four orbiters is very "success" oriented. The lack of provisions for a fifth orbiter may turn out to be more "stop and go" programming which has plagued the U.S. space program in the past. If the Federal government is unable to commit to a fifth orbiter because of a current lack of requirements, we recommend that Congress encourage a private industry group to purchase the fifth orbiter. Once an assembly line as complicated as the orbiter's is shutdown, it will be virtually impossible and prohibitively expensive to reopen it.

SPACE PLATFORM

We recommend that a space platform/station be a cornerstone of this Nation's space policy. A permanent presence in space is at least as important as some of our most tenacious goals on the surface of the earth. Such a presence is essential for future economic benefits as well as defense. This and other programs should be planned effectively by NASA so that an orderly funding pattern over the long term can be established for industry and the universities.

SUMMARY AND RECOMMENDATIONS

SUMMARY

We are pleased with the increase in the NASA budget, particularly because it includes new starts like the Venus Radar Mapper and the Advanced Communications Technology Satellite.

Most importantly, however, we encourage the creation and adoption of a well defined National Space Policy with clear-cut national goals and the rapid commercialization of programs like Expendable Launch Vehicles, Shuttle and Shuttle Operations.

RECOMMENDATIONS

We recommend:

1) that Congress legislate an enduring, bipartisan National Space Policy listing specific goals that will excite and capture the Nation's imagination;

2) that satellite ferrying and retrieval spacecraft be developed as part of the National Space Policy;

3) that Congress recommend the privatization of expendable launch vehicle operations;

4) that Congress expedite privatization of the operational Landsat systems and that NASA's Landsat research and development team continue to develop advanced land remote-sensing systems;

5) that Congress recommend that NASA develop advanced communciations satellite systems as a continuing mission;

6) that Congress recommend that NASA restore its technology transfer/utilization activities;

7) that Congress encourage a private industry group to purchase a fifth orbitor;

8) that a manned space platform be specifically included in the National Space Policy;

ACKNOWLEDGMENTS

The ASME would like to thank the Subcommitte for this opportunity to comment on the NASA FY-84 budget. Persons contributing to the preparation of this statement are listed below.

Dr. Serge Gratch, President, ASME
Mr. Phillip J. Legendre, Former ASME Congressional Fellow
Dr. Buford Price, Director, University of California-Berkeley Space Sciences Laboratory
Mr. John W. Robinson, Chairman, ASME Aerospace Division
Dr. Robert F. Steidel, Jr., Associate Dean of Engineering, University of California-Berkeley.
Mr. George C. Wiedersum, Jr., Vice President, ASME Energy Conversion Group

Mr. VOLKMER. Thank you very much, Mr. Robinson.

To divert from the normal procedure, Mr. Brown, I will recognize you first.

Mr. BROWN. Well, obviously, I would first like to express my appreciation to you and your organization for mentioning my bill. I think that that endorsement is important; but more important is the achievement of a space policy posture for this country that will enable us to move ahead. In the light of having introduced the bill now for a few years, I have been wondering what we could do to enhance the possibilities of getting that space policy. I am still looking for that.

We had an interesting exercise last fall in which the administration raised a legitimate question about whether the policy we had been following for several years, in fact a couple of generations, with regard to the Federal role in aerospace research and development in general, was justified. It appeared on the surface that to continue to support R&D for a mature industry ran contrary to the philosophy of seeking to privatize as much as possible those functions which could be privatized. The result of that apparently fairly extensive analysis was to find a new base of support for continuing to fund aerospace R&D in cooperation with the private industry.

Now, what I am wondering is, why can't we recognize the need to develop a comprehensive civilian space policy which will lay out the interrelationships between the Government role and private industry role and allow us to move forward aggressively in maintaining a posture of noble leadership in this area? Do either of you gentlemen know anybody in the White House that we could talk to about this?

Mr. ROBINSON. No. But I think we need to proceed to do that. NASA policy established back in 1958, (it is 25 years old) was pretty uncertain as to where we would be today. But clearly the development activity of NASA is probably the vital activity that has been done very well. We need to continue doing that. I think where they get involved in perhaps areas where commercialization is possible we need to look at it. If we don't do it our foreign competitors, the French, the Japanese, and who knows who else, are getting their ducks in line. We need to reorganize. I think we need to rethink the whole policy of the approach we are taking.

If you look at things today, we know that in the future we are going to be going into the commercialization of a lot of the products that NASA is developing. I think it is not unreasonable to consider that maybe a high-technology transfer rather than common technology transfer should be pushed. The Government needs to get involved in, and maybe the Congress, in how you transfer Government property to industry; but, I would rather see it given to somebody in the United States than have it sitting here while we debate and foreign enterprises start developing their capability. We have to be competitive. We have got to get operational. I think we have the ability to do that even if the Government has to subsidize, such as the French are doing, we need a policy that involves all of us.

We need to have the basic policy that NASA has been good at. But we need to bridge the gap between the existing operations of NASA and the private sector on large-scale projects as we did in our development for Apollo and Gemini and Mercury.

Mr. BROWN. Well, when you think back it is hard to understand how John F. Kennedy could justify committing this country to a $25 billion expenditure to land a man on the Moon, because there wasn't a bit of commercial good in it that I can see just offhand. But he saw the positive benefit to this country's role of leadership in the world and committed us to do that, and we are at a stage now further along where we can see the direct relationship between this and our industrial and commercial survival as the leader in the world.

We don't seem to have yet a critical mass of leadership that is willing to commit itself in that direction. That is the problem that I am grappling with here. Maybe this subcommittee can provide that critical mass of leadership.

Mr. ROBINSON. Perhaps the other thing that is missing is the fact that the industry doesn't have a clear visibility of what the Government is going to let go. What do we focus on from the industry standpoint?

Mr. BROWN. Well, any clear-cut statement of policy I think would help to define that, would make it clear that every aspect that had commercial viability would be spun off for commercial application. We have done that in other fields. We did it in nuclear energy, for example.

Mr. VOLKMER. I wonder if 25 years ago when the policy was enacted, there was any idea that we would have these commercial applications at this time?

Mr. BROWN. There was a hope but there was no concrete understanding.

Mr. Chairman, I have no further questions, but I am grateful to these gentlemen for putting this problem in perspective, and I think they have helped, to some degree at least, to establish the momentum necessary to achieve that civilian space policy formulation that I think we need very badly.

Mr. VOLKMER. I thank the gentleman.

Now I will recognize the gentleman from New Mexico, Mr. Lujan.

Mr. LUJAN. Thank you. You know all three panels have said we ought to have a space policy. It seems to me like we have one. We

first went into space, orbited the Earth; then we had them orbit the Moon; finally we landed somebody on the Moon; now we have the reusable shuttle. We have got that in pretty good shape. It has made enough trips, so we are going to build a space station although we haven't determined when it is going to be, and we haven't committed to it. As a matter of fact, in between times we are taking trips up to Jupiter and we are going to Venus and check all that out.

How much more can we define as a space policy? The President has said we want a permanent presence in space. He didn't say manned, but we will have a permanent presence in space.

In considering the question of whether we have a space policy, nobody pays any attention to that. I don't quite understand.

Mr. ROBINSON. Maybe I can help out here, hopefully clarify it. You know we have a policy. We have goals and we have programs, and they are all different. The existing policy of maintaining a permanent presence in space is just a policy We need to address real goals for without goals, dollars, and talent run a risk of being misdirected, and without programs, goals tend to become meaningless. We have got to have something in industry that we can get our hands on. We have got to have a goal that is related to a program. We need a commitment, for example, to a manned space station. We need to have a timetable to put that into operation.

Mr. LUJAN. Do you think that is a little premature, since they are just doing the studies now to see how——

Mr. ROBINSON. We don't know how we proceed from the study to a product. If we don't proceed to a product, we may have other countries doing it. I mean we need to work these types of things. The goals need to be clearly and very specifically identified to the best of our ability in the policy. Not just a policy but goals to do something in the industry. Then industry can grab it, the university can grab it, we can all address it, we can start teaching it in our elementary and secondary schools.

There are a lot kids that would love to get into space; they don't know what to focus on. We need to focus our capability. We need to focus the problems, the projects that we are going for. We said we would send man to the Moon. That was a goal. It had a program identified. It had something we could work toward. I think talent we have had the last 25 years is probably people my age and a lot have retired now. We need to bridge the gap between generations. The goals should span over a generation to where we get young people coming up excited, not just a near term for the next 5 years. We ought to be looking ahead to where we are going and our goals ought to be definitized to the point that we can start training our young people.

Mr. LUJAN. How specific can we get?

Mr. ROBINSON. Pretty specific would be: We are committed to putting a space station into orbit, low Earth orbit, in this decade.

Mr. LUJAN. You don't think that is our goal. You don't think——

Mr. ROBINSON. I don't see it. Maybe I am missing something.

Mr. LUJAN. Nobody has written it down.

Mr. ROBINSON. We need to write it down.

Mr. LUJAN. In 1993, I don't know I will be here that long, but I will see you somewhere within 1993 and we will have a manned station.

Mr. ROBINSON. We need to identify the goals we can all work on. We are not all working together. We need to develop the teamwork of the industry, the Government. I am not involved in the study myself. This is my own opinion. If we are shuffling studies back and forth, you know, we need to focus together and all work to that goal. It is not NASA's fault. The Congress, the highest levels of the Government, need to say, "these are our goals."

Mr. LEGENDRE. When President Kennedy said we are going to the Moon, we in the industry felt confident that we were going to go to the Moon and we were able to gear our energies, our companies, our resources, to work toward that goal. As he indicated, John indicated, what we see now are studies and we know from other programs that have never come off the drawing board that you can actually study something until it is no longer useful or is studied to death. Generally, according to our Constitution, the executive branch is expected to take that responsibility, to announce we are going into low Earth orbit with a space station and part of that space station will be a factory. And if the executive branch does not take that responsibility, then, as I understand it, it is the responsibility of the Congress to try to put forth strong goals and positions.

Mr. LUJAN. All right.

Mr. BROWN. Would the gentleman allow me to comment?

Mr. LUJAN. Certainly.

Mr. BROWN. I know that the gentleman is as interested in having us maintain a good space program as anyone. We sometimes exaggerate the extreme positions here. Actually, when the President made his space policy announcement last July I think it was kind of in a tilt situation. As I understand it, he was being advised by some of his advisers to announce a space station, commit us to it, to move ahead with a more vigorous civilian space program. But he ended up tilting somewhat toward a military program, a strong commitment to a military space program.

He left us, therefore, with a slight feeling of not so much commitment to a civilian space program. Not a follow on to the Landsat program. Not some of the other things that we would like to feel a commitment to. But it isn't as if we don't have a commitment. It is just that there is a little insecurity about how big and how long it is going to last.

Mr. LUJAN. Maybe it is a difference of how we view things. I view things that the next logical step is a space station and manned station, and that there will be a factory there and needs will dictate how big it is going to be, or a laboratory will be part of it. There is no question in my mind that that is the direction that we are going. So I am saying that we don't need to have the President say, well, we are going to have a space station, and we are going to have a factory and laboratory there. We just move on ahead, because we are funding NASA and we will move with them.

I guess that is the way I see the policy developing. We do what we know we are going to do without——

Mr. VOLKMER. Being announced.

Mr. LUJAN. We don't have to have the President say that. As a matter of fact, when Kennedy said that we were going to go to the Moon, it was a reaction to Soviet supremacy at that time. We didn't want it. It seems like this country works like that. The Russians are going to have an orbiter one of these days and a space station there as well. When they have one—I hope we have it before them. But when they get to a point that they are going to be there, whoever is President at that time will enunciate the policy that we are going to have a bigger station.

Mr. ROBINSON. I guess we don't——

Mr. LUJAN. We may have it in geosynchronous, if they have one in low Earth orbit.

Mr. VOLKMER. We will go way out.

Mr. LUJAN. Pardon me?

Mr. ROBINSON. We don't shoot until we see the white of the eyes. But I think in the economic environment of the world we may be seeing the white of the eyes now, if we don't plan our strategy carefully and get our resources working together. We have a major challenge ahead of us. To say we are just going to do it, you know, how do I go back and tell all our 100,000 people, you know, clearly, guys, this is what your direction is. Part of it may just be a better way to get the public informed.

Mr. LUJAN. Go tell them Lujan said so.

Thank you, Mr. Chairman.

Mr. VOLKMER. Perhaps the gentleman from New Mexico should converse a little more with Mr. Keyworth.

Mr. LUJAN. That is right. Well, there is a problem there.

Mr. VOLKMER. I now recognize Mr. Bateman.

Mr. BATEMAN. Thank you, Mr. Chairman.

This has gotten even more intensely interesting for me because somebody started talking about civics instead of physics. I know a little bit more about civics than physics. I am not sure we are in entire accord on the constitutional view of the role of the Executive, necessarily, to make policy. Certainly, it is very appropriate for them to propose policy, but I thought they administered and executed the laws that we adopted pursuant to some perceived national policies.

But be that as it may, I will return to something that I find interesting in your written statement with reference to commercialization or privatization. The statement seems, as I read it, to commend going forward as soon as practical with the privatization or commercialization of the Landsat program. I would first inquire, how ripe do you view Landsat for commercialization or privatization? Is it ready now, or is it one of these goals that we certainly should move toward? Is it ripe? Is it ready?

Mr. LEGENDRE. There are at least two companies in this country that seem to think that part or all of Landsat is ready. As probably everyone here knows, Comsat would like to take a whack at taking over Landsat and the weather satellites for an all-up system. In the recent past, the Halbouty Commission, commissioned by the Secretary of Commerce, had a number of recommendations, chief of which——

[Pause.]

Mr. VOLKMER. Continue. We will try to finish this up by a quarter after.

Mr. LEGENDRE. As the Commission recommended, they were recommending that the Department of Commerce put the Landsat system out for bid and evaluate the resulting proposals that would come in. And, depending upon the feasibility of the proposals, they would find out if it is feasible for the entire Landsat system to go to one company, or if it is feasible for the Landsat plus the weather satellites to go to a company. Further, would it be better for company A to take the ground segment and company B take the space segment or perhaps, as Senator Cannon had suggested in his proposed legislation last year, would it be better just to privatize the ground segment now and consider privatizing the space segment later.

It was the feeling, as I observed that particular Commission when they returned their findings, that they would send out the proposals, get the answers, check the feasibility, and select one of those ways. If it turns out that it is not feasible, after evaluating these proposals, to privatize any of the Landsat, then it is felt—we feel the same way—that NASA should continue developing future Landsat-type systems, such as improved land remote sensing systems, and that NOAA continue in the actual operational portion or phase of the Landsat system.

Mr. BATEMAN. I am struck by the fact, and I hope it has some significance, frankly, that in your comments on privatization, commercialization, you restrict it to Landsat. There is no reference to privatization, commercialization of Metsat. Was that by design or by oversight? Heaven forbid.

Mr. LEGENDRE. No; it was discussed every time they had a public meeting. It was the Comsat proposal to try and handle both operations, whereas some of the other people that were——

Mr. BATEMAN. Excuse me, but I am focusing on what I am reading here in your statement. Whatever this other committee did or didn't do, whatever Comsat wants or doesn't want to do, there is to me a rather glaring failure to include Metsat as being presently ripe for commercialization. Does that bespeak an actual point of view?

Mr. LEGENDRE. That is only my point of view. That is not the point of view of the society. The weather satellites did not enter into their evaluation.

Mr. BATEMAN. If there had been some perception in your society that that were ripe for it, ready for it, I presume they would have been included.

Mr. LEGENDRE. That is correct.

Mr. BATEMAN. Am I correct, therefore, in surmising that your society, those that were in leadership and directing a study and formulation of a recommendation, must have thought Metsat wasn't ready?

Mr. LEGENDRE. I wouldn't say that. I don't believe that issue was wrung out as much as some others were that we responded to. I was perhaps a little closer to that issue than they were. But the subject of Landsat, though, the definite feeling is that Landsat is ready for commercialization along the lines that were recommended by that Commission.

Mr. BATEMAN. The name of the Commission is what?

Mr. LEGENDRE. H-a-l-b-o-u-t-y. That was the name of the man that was chairing that Commission for the Secretary of Commerce.

Mr. BATEMAN. Thank you very much.

Mr. VOLKMER. Are you through?

Mr. BATEMAN. Yes, sir. I don't know whether I am finished, but I am done.

Mr. VOLKMER. You are finished.

In the event this committee or any other appropriate committee in the Senate or House would attempt to look at the question of a new space policy, or review the present space policy, would your organization be willing to look into that and give us the benefit of your thoughts in regard to that?

Mr. ROBINSON. Yes, sir, we would be very pleased to do that.

Mr. VOLKMER. All right. Do you have any position on whether, assuming we would have a space station, it is necessary to man it?

Mr. ROBINSON. We feel that, ultimately, in that discussion, yes, it would be manned. It would have both manned and automated operations.

Mr. VOLKMER. Those are all the questions I have. I want to thank both of you very much for being here. We appreciate your testimony.

With that the subcommittee will adjourn.

[Whereupon, at 4:01 p.m., the subcommittee was adjourned, to reconvene subject to the call of the Chair.] F6601

NASA

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: C:LVN:mdd:C-8613f

FEB 03 1983

Honorable Harold L. Volkmer
Chairman
Subcommittee on Space Science
and Applications
Committee on Science
and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

Enclosed are the responses to the questions forwarded to us by the former chairman on December 8, 1982, regarding NASA's FY 1984 Research and Development budget request. We are unable to provide answers to questions 9 and 10 at this time. Rather than delay our response further we are providing answers to questions one through eight and will supply the others as soon as possible.

Sincerely,

John F. Murphy
Assistant Administrator
for Legislative Affairs

Enclosure

(1475)

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of: C:LVN:C-8613f

MAR 15 1983

Honorable Harold L. Volkmer
Chairman
Subcommittee on Space Science
and Applications
Committee on Science
and Technology
House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

In our letter of February 3, 1983, we forwarded the responses to your questions from the December 8, 1982, letter minus the responses to questions 9 and 10. Enclosed are the responses to those outstanding questions.

We are extremely sorry for the delay in providing this information and hope that the delay has not caused an undue burden.

Sincerely,

Patrick A. Templeton
Deputy Assistant Administrator
for Legislative Affairs

Enclosure

APPENDIX

QUESTIONS SUBMITTED BY CHAIRMAN FLIPPO.

QUESTION 1:

Please furnish the following tabulation, by major programs, for the FY 1984 budget request:

a. the original recommended budget to OMB
b. the adjustments made
c. the submission to Congress
d. brief comment on the adjustments made, if any,
e. the comparative FY 1983 operating plan figure
f. please assign an agency priority to those programs requested from OMB but not presented to Congress

ANSWER 1:

See the enclosed table.

QUESTION 2:

Please furnish the following information, by NASA Center and by major program for the FY 1984 budget request:

a. original Center request to NASA Headquarters
b. the adjustments made
c. brief comments on adjustments made
d. the submission to Congress as allocated by Center, and
e. the comparative FY 1983 operating plan figure, by Center

ANSWER 2:

See the enclosed table.

TABLE A

COMPARISON OF OMB BUDGET REQUEST TO CONGRESSIONAL BUDGET REQUEST

	FY 1983 Current Estimate	FY 1984 Budget Request to OMB	Δ	FY 1984 Budget Request to Congress	Remarks
Research and Development					
Space Transportation Capability Dev.	2144.1	2154.5	-227.1	1927.4	
Shuttle Production & Cap. Dev.	1729.3	1630.3	-130.3	1500.0	Reduction of projected inflation rate; deletion of OV-105; and an increase for procurement of spare structures for orbiter fleet.
Fifth Orbiter		(200.0)	(-200.0)	(--)	
Upper Stages	167.0	195.2	-52.0	143.2	Reduction of funds reflects projected inflation rate; cancellation of two IUS vehicles due to TDRSS reformation; adjustment to Centaur due to FY 83 Appropriation and deletion of RL-10.
Spacelab	121.2	121.5	-1.9	119.6	Reduction of projected inflation rate.
Engineering & Technical Base	70.3	95.0	-1.9	93.1	Reduction of projected inflation rate.
Payload Operations & Support Equip.	44.4	54.0	-.8	53.2	Reduction of projected inflation rate.
Advanced Programs	11.9	15.0	--	15.0	Includes $6M for Space Station.
Space Station Definition Augmentation	--	30.0	-30.0	--	Deletion of funds for proposed augmentation.
Tethered Satellite Dev. Augmentation	--	3.3	--	3.3	
Advanced Capability Development	--	5.0	-5.0	--	Deletion of funds for proposed augmentation.
Teleoperator Maneuvering System ØB		5.2	-5.2	--	Deletion of funds for proposed new start.
Space Transportation Operations	1453.7	1745.5	-174.9	1570.6	
Shuttle Operations	1370.7	1687.7	-167.1	1520.6	Reduction of projected inflation rate; deferral of obligations from FY 83 due to TDRSS contract changes; no provision for additional external tank delivery margins and revised estimate of anticipated reimbursements.
Expendable Launch Vehicles	83.0	57.8	-7.8	50.0	Reduction of funds due to restructuring of Delta program.
Physics and Astronomy	441.0	530.6	-16.0	514.6	
Space Telescope Development	137.5	120.6	--	120.6	
Spacelab Payload Dev. & Msn. Mgmt.	83.0	101.0	-8.1	92.9	Reduction of funds for proposed augmentation.
Gamma Ray Observatory	34.5	89.8	--	89.8	
Explorer Development	34.3	49.4	-.7	48.7	Reduction of projected inflation rate.
Mission Operations & Data Analysis	74.8	79.5	--	79.5	

	FY 1983 Current Estimate	FY 1984 Budget Request to OMB	Δ	FY 1984 Budget Request to Congress	Remarks
Research and Analysis	28.8	29.8	--	29.8	
Suborbital	48.1	60.5	-7.2	53.3	Reduction of funds for proposed augmentation and projected inflation rate.
Life Sciences	55.7	59.6	-.6	59.0	
Flight Experiments	24.0	23.0	--	23.0	
Research and Analysis	31.7	36.6	-.6	36.0	Reduction of projected inflation rate.
Planetary Exploration	186.4	211.1	-5.7	205.4	
Galileo Development	91.6	79.5*	--	79.5*	
International Solar Polar Msn. Dev.	6.0	8.0	--	8.0	
Mission Operations & Data Analysis	38.5	45.9	-2.5	43.4	A general reduction in planetary science.
Research and Analysis	50.3	48.7	-3.2	45.5	A general reduction to planetary science.
Venus Radar Mapper Mission	--	29.0	--	29.0	
Space Applications	351.0	363.7	-74.7	289.0	
Landsat-4	61.7	15.8	--	15.8	
Shuttle Payloads	13.8	15.3	-.3	15.0	Reduction of projected inflation rate.
AgRISTARS	15.0	4.0	-4.0	--	Termination of NASA AgRISTARS program, as previously planned.
Geodynamics	19.2	22.9	-2.4	20.5	Reduction of funds for proposed augmentation and projected inflation rate.
Laser Network Operations	7.0	7.6	-.1	7.5	Reduction of projected inflation rate.
Solid Earth Obs. Research & Analysis	13.7	16.9	-2.3	14.6	Reduction of funds for proposed augmentation and projected inflation rate.
Extended Mission Operations	1.8	1.0	--	1.0	
Environmental Obs. Research & Analysis	86.4	93.6	-1.7	91.9	Reduction of proposed level of funding.
Environmental Obs. Shuttle Payloads	3.7	7.7	-.1	7.6	Reduction of projected inflation rate.
Upper Atmosphere Res. Satellite Exp.	14.0	31.3	-11.3	20.0	Reduction of proposed increase based on rephasing of development efforts.
Upper Atmosphere Research Satellite	--	15.6	-15.6	--	Development of Upper Atmosphere Research Satellite not initiated.
Earth Radiation Budget Experiment	24.0	15.5	--	15.5	
Other Environmental Observations	28.8	28.0	--	28.0	

*NASA requested and OMB approved the addition of $13.0 million to reimburse the Department of Energy for continued development of the Radioisotope Thermoelectric Generators required for Galileo and ISPM.

	FY 1983 Current Estimate	FY 1984 Budget Request to OMB	△	FY 1984 Budget Request to Congress	Remarks
Materials Processing	22.0	30.3	-8.7	21.6	Reduction of proposed level of funding.
Adv. Communications Tech. Satellite (ACTS) Payload	20.0	19.0	-14.0	5.0	Reduction of proposed level of funding based on the assumption of cost contribution from industry.
Other Communications	8.7	16.4	-4.1	12.3	Mobile Satellite support activities not initiated, and minor reduction in proposed increase in Communications activities.
Search and Rescue	3.7	3.8	--	3.8	
Information Systems	7.5	19.0	-10.1	8.9	Reduction of proposed level of funding.
Technology Utilization	9.0	10.0	-6.0	4.0	Deletion of enhancements, and reduced level of activity.
Aeronautical Research and Technology	280.0	343.9	-43.6	300.3	
Ongoing Research & Technology Base	197.7	234.7	-6.9	227.8	Reduction of projected inflation rate.
Aviation Safety & Operating (R&T Base) Augmentation	--	5.0	-5.0	--	Deletion of proposed augmentation for research and technology base work.
Ongoing Systems Technology	82.3	60.2	-20.7	39.5	Deletion of funds for ongoing Systems Technology programs. These programs included: Laminar Flow Control; Advanced Transport Operating Systems; and Advanced Turboprop Systems.
Numerical Aerodynamic Simulation Aug.	--	20.0	--	20.0	
Advanced Composite Structures Tech. Aug.	--	5.0	--	5.0	
Small Engine Component Technology Aug.	--	4.0	-4.0	--	Deletion of funds for new systems technology project.
Technology for Next Generation Rotorcraft Augmentation	--	8.0	--	8.0	
Large Rotorcraft Technology Aug.	--	2.0	-2.0	--	Deletion of funds for new systems technology project.
Advanced Turbofan Research Augmentation	--	5.0	-5.0	--	Deletion of funds for new systems technology project.
Space Research and Technology	120.0	169.2	-35.8	133.4	
Ongoing Research and Technology Base	115.1	126.0	-5.8	120.2	NASA initiated transfer to Systems Technology ($4M) and projected inflation rate.
University Research (R&T Base) Aug.	--	5.0	-5.0	--	Deletion of funds for new university instrumentation program.
Space Station Technology (R&T Base) Aug.	--	30.0	-24.0	6.0	Deletion of proposed augmentation for disciplinary long-term space station efforts.
Ongoing Systems Technology	4.9	3.2	+4.0	7.2	NASA transfer from R&T Base to Systems Technology.
In-Space Flt. Facilities & Exp. Aug.	--	5.0	-5.0	--	Deletion of proposed augmentation for systems technology projects.

	FY 1983 Current Estimate	FY 1984 Budget Request to OMB	△	FY 1984 Budget Request to Congress	Remarks
Standards and Practices	3.0	4.6	--	4.6	
Space Tracking and Data Acquisition	498.9	726.0	-25.8	700.2	
Space Network	103.8	310.8	-16.1	294.7	Reduction of funds for TDRSS support and projected inflation rate.
Ground Network	242.4	236.9	-5.4	231.5	Reduction of projected inflation rate.
Communications and Data Systems	139.3	163.7	-3.9	159.8	Reduction of projected inflation rate.
Advanced Systems	13.4	14.6	-.4	14.2	Reduction of projected inflation rate.
TOTAL RESEARCH AND DEVELOPMENT	5542.8	6318.7	-610.2	5708.5	
CONSTRUCTION OF FACILITIES	97.5	157.6	-7.1	150.5	
Projects Approved		152.5	-2.0	150.5	Reduction in the level of funding requested for minor construction, repair and facility planning and design.
Construction of addition to Research Projects Laboratory-GSFC		1.9	-1.9	--	Deletion of augmentation to provide space for automatic data processing equipment used to support unmanned earth orbiting satellite programs.
Rehabilitation of Technical Support Building-WFC		3.2	-3.2	--	Deletion of augmentation for rehabilitation and modification to technical support building
RESEARCH AND PROGRAM MANAGEMENT	1199.1	1297.0*	-49.5	1247.5*	Deletion of funds for proposed augmentations and reduction of funds reflects projected inflation rate.
TOTAL NASA	6839.4	7773.3	-666.8	7106.5	

*Includes adjustment to present pay rates

TABLE B

National Aeronautics and Space Administration

FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

HEADQUARTERS
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	Δ	FY 1984 Budget Request	Remarks
Space Transportation Capability Dev.	104.3	173.7	-52.7	121.0	Reallocation of program reserves and reduced provision for inflation.
Space Transportation Operations	21.5	65.4	-45.7	19.7	Reallocation of program reserves and reduced provision for inflation.
Physics and Astronomy	29.8	32.3	—	32.3	
Life Sciences	11.2	12.4	—	12.4	
Planetary Exploration	36.3	43.0	—	43.0	
Space Applications	34.9	38.4	—	38.4	
Technology Utilization	5.5	7.0	-4.7	2.3	Reduced funding for Industrial Application Centers.
Aeronautical Research and Technology	5.0	5.3	-.3	5.0	Deletion of proposed increased funding in research and technology base activities.
Space Research and Technology	4.7	5.0	—	5.0	
Tracking and Data Acquisition	64.1	17.5	+196.1	213.6	TDRSS contract payments to be made from Headquarters rather than Goddard.
TOTAL	317.3	400.0	+92.7	492.7	

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FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

AMES RESEARCH CENTER
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	△	FY 1984 Budget Request	Remarks
Space Transportation Operations	3.0	3.2	—	3.2	
Physics and Astronomy	19.3	22.7	-1.1	21.6	Reduction in proposed increased funding for airborne research.
Life Sciences	22.0	23.1	—	23.1	
Planetary Exploration	17.2	12.3	—	12.3	
Space Applications	4.5	4.4	—	4.4	
Technology Utilization	.1	.4	-.3	.1	Deletion of funds for enhancement of technology applicatic s project in rehabilitation enhancements.
Aeronautical Research and Technology	96.0	128.7	-6.5	122.2	Deletion of High-Performance Aircraft Technology and Integrated Digital/Electric Aircraft proposed enhancements. Reduction to Technology for Next Generation Rotorcraft enhancement.
Space Research and Technology	10.0	14.9	-3.4	11.5	Deletion of In-Space Flight Facilities and Experiments, University Research and Spacecraft Technology proposed enhancements.
Tracking and Data Acquisition	4.2	6.8	-.2	6.6	General reduction to Center request.
TOTAL	176.3	216.5	-11.5	205.0	

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FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

GODDARD SPACE FLIGHT CENTER
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	Δ	FY 1984 Budget Request	Remarks
Space Transportation Capability Dev.	2.9	1.5	--	1.5	
Space Transportation Operations	81.4	44.4	+5.0	49.4	Delta launch program adjustments.
Physics and Astronomy	120.6	199.2	-4.7	194.5	Increase for Gamma Ray Observatory development efforts, offset by reduction of Suborbital Program enhancement and reduction in Spacelab Payload enhancement.
Life Sciences	.1	.1	--	.1	
Planetary Exploration	5.5	4.3	--	4.3	
Space Applications	200.7	174.4	-21.1	153.3	Increase for operation of NIMBUS and ISEE missions, offset by reduction of Crustal Dynamics augmentation, and reduction in Upper Atmosphere Research Satellite Experiment and Landsat requests.
Technology Utilization	1.0	.9	-.5	.4	Deletion of biomedical application enhancement.
Aeronautical Research and Technology	.5	.5	--	.5	
Space Research and Technology	10.1	11.8	-1.2	10.6	Reduction to proposed Space Station Technology augmentation.

	FY 1983 Current Estimate	FY 1984 Center Request	△	FY 1984 Budget Request	Remarks
Tracking and Data Acquisition	317.6	588.9	-228.8	360.1	Deletion of funds for TDRSS Contract payments to be made from Headquarters, rather than GSFC; reduction in amount requested for Space Network Operations & Systems; and reductions in support of other program areas.
TOTAL	740.4	1026.0	-251.3	774.7	

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FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

JET PROPULSION LABORATORY
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	△	FY 1984 Budget Request	Remarks
Space Transportation Capability Dev.	.8	1.4	--	1.4	
Physics and Astronomy	18.3	20.5	--	20.5	
Life Sciences	1.0	1.1	--	1.1	
Planetary Exploration	120.2	154.1	-15.1	139.0	Reduction due to cancellation of kick stage development for Galileo and ISPM.
Space Applications	45.6	52.9	--	52.9	
Technology Utilization	.7	.7	-.4	.3	Deletion of funds for robotics enhancement.
Aeronautical Research and Technology	.5	.5	--	.5	
Space Research and Technology	22.0	26.4	-2.9	23.5	Deletion of In-Space Flight Facilities and Experiments, and Spacecraft Technology proposed new enhancements. Reduction to proposed Space Station Technology augmentation.
Tracking and Data Acquisition	110.6	113.9	-7.0	106.9	Defer implementation of new equipment to support High Earth Orbital (HEO) missions.
TOTAL	319.7	371.5	-25.4	346.1	

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FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

JOHNSON SPACE CENTER
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	△	FY 1984 Budget Request	Remarks
Space Transportation Capability Dev.	1092.4	1021.0	-77.7	943.3	Reduced funding reflects deletion of requested fourth Shuttle Training Aircraft, second Shuttle Carrier Aircraft modifications, and Spacelab cryo pallet; reductions in support contractor manning levels, inflation provisions, and Center reserves; reductions offset partially by increased provisions for Centaur modifications.
Space Transportation Operations	370.7	467.0	-78.6	388.4	Reductions in planned manpower levels and Center reserves; deferral of equipment procurements consistent with revised schedules.
Physics and Astronomy	8.5	8.7	--	8.7	
Life Sciences	19.2	20.0	--	20.0	
Planetary Exploration	7.3	6.8	--	6.8	
Space Applications	13.6	12.6	-9.0	3.6	Reduction of funding to continue AgRISTARS program.
Technology Utilization	--	.2	-.2	--	Deletion of funds for technology applications in hyperthermia activities.
Aeronautics Research and Technology	.2	.2	--	.2	
Space Research and Technology	13.0	22.5	-8.0	14.5	Deletion of Spacecraft Technology and In-Space Flight Facilities and Experiments proposed enhancements. Reduction to proposed Space Station Technology augmentation.
TOTAL	1524.9	1559.0	-173.5	1385.5	

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FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

KENNEDY SPACE CENTER
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	△	FY 1984 Budget Request	Remarks
Space Transportation Capability Dev.	141.9	158.0	+2.6	160.6	Increased funding for Shuttle turnaround enhancements.
Space Transportation Operations	347.2	383.0	-28.1	354.9	Reductions due to different inflation projections; manpower reductions based on revised assessments; partially offset by provision for flight readiness firing and revised implementation schedule for Shuttle Processing Contract.
Physics and Astronomy	5.0	7.1	—	7.1	
Life Sciences	1.5	1.5	—	1.5	
Technology Utilization	.3	.1	—	.1	
Space Research and Technology	.1	--	+.3	.3	Increased funding for research and technology base activities.
TOTAL	496.0	549.7	-25.2	524.5	

QUESTION 3:

Please furnish by major line item, the NASA operating plan for FY 1982 and FY 1983 with comments on adjustments, if any.

ANSWER 3:

See the enclosed table.

National Aeronautics and Space Administration

FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

LANGLEY RESEARCH CENTER
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	Δ	FY 1984 Budget Request	Remarks
Space Transportation Capability Dev.	.4	.9	--	.9	
Life Sciences	.4	.5	--	.5	
Space Applications	9.0	9.1	--	9.1	
Technology Utilization	.8	.9	-.5	.4	Reduced funding for biomedical technology applications activities.
Aeronautical Research and Technology	94.3	112.3	-19.0	93.3	Deletion of funds for ongoing Laminar Flow Control and Advanced Transport Operating Systems Technology programs. Deletion of Aviation Safety & Operating Systems, High-Performance Aircraft Technology, and Integrated Digital/Electric Aircraft proposed enhancements. Reduction to Technology for Next Generation Rotorcraft enhancement.
Space Research and Technology	28.0	45.2	-14.7	30.5	Deletion of In-Space Flight Facilities and Experiments, University Research, and Spacecraft Technology proposed enhancements. Reduction to proposed Space Station Technology augmentation.
TOTAL	132.9	168.9	-34.2	134.7	

National Aeronautics and Space Administration

FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

LEWIS RESEARCH CENTER
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	Δ	FY 1984 Budget Request	Remarks
Space Transportation Capability Dev.	120.1	10.0	+102.2	112.2	Increase reflects development and procurement of Centaur, offset by revised planning for engine technology requirements.
Space Applications	25.5	28.1	-16.2	11.9	Reduced level of funding for Advanced Communications Technology Satellite based on assumption of industry contribution, and reduced Materials Processing enhancement request.
Technology Utilization	.3	.3	-.1	.2	Deletion of funds for biomedical application enhancement.
Aeronautical Research and Technology	83.0	97.9	-19.9	78.0	Deletion of Small Engine Component Technology, Aviation Safety & Operating Systems, Advanced Turbofan Research, High-Performance Aircraft Technology, and Integrated Digital/Electric Aircraft Technology proposed enhancements. Reduction to Technology for Next Generation Rotorcraft enhancement.
Space Research and Technology	22.0	35.5	-8.0	27.5	Deletion of In-Space Flight Facilities and Experiments, University Research, and Spacecraft Technology proposed enhancements. Reduction to proposed Space Station Technology augmentation.
TOTAL	250.9	171.8	+58.0	229.8	

National Aeronautics and Space Administration

FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

MARSHALL SPACE FLIGHT CENTER
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	△	FY 1984 Budget Request	Remarks
Space Transportation Capability Dev.	676.3	693.0	-112.6	580.4	Reductions due to reduced provision for inflation; support manpower assessment; cancellation of planetary IUS and reduction in IUS procurement buy size; deletion of smooth tank design change proposed; reductions in Center reserve estimates; and rescheduling of main engine controller redesign activities. Partially offset by increased allowance for additional external tank rate tooling and main engine replacement hardware.
Space Transportation Operations	629.9	852.0	-97.0	755.0	Reductions due to different inflation assumptions; support manpower estimates; reserves estimated by the Center; and phaseout of operations support control center.
Physics and Astronomy	239.5	248.5	-18.7	229.8	Reduction of enhancement to Spacelab payload development activities and deletion of funding for initiation of Gravity Probe-B development activities.
Life Sciences	.3	.3	--	.3	
Space Applications	15.1	18.4	-4.0	14.4	Deletion of proposed Materials Processing enhancement.
Technology Utilization	.3	.5	-.3	.2	Deletion of proposed biomedical enhancement.
Aeronautical Research and Technology	.5	.6	--	.6	

	FY 1983 Current Estimate	FY 1984 Center Request	Δ	FY 1984 Budget Request	Remarks
Space Research and Technology	13.0	17.4	-2.8	14.6	Deletion of In-Space Flight Facilities and Experiments proposed enhancement. Reduction to proposed Space Station Technology augmentation.
Tracking and Data Acquisition	2.4	13.0	--	13.0	
TOTAL	1577.3	1843.7	-235.4	1608.3	

National Aeronautics and Space Administration

FY 1984 BUDGET REQUEST
RESEARCH AND DEVELOPMENT

NATIONAL SPACE TECHNOLOGY LABORATORIES
(millions of dollars)

	FY 1983 Current Estimate	FY 1984 Center Request	△	FY 1984 Budget Request	Remarks
Space Transportation Capability Dev.	5.0	6.1	--	6.1	
Space Applications	2.1	1.1	--	1.1	
TOTAL	7.1	7.2	--	7.2	

Table C

National Aeronautics and Space Administration

FY 1982 and FY 1983 Operating Plans
By Budget Line Item
(dollars in millions)

Research and Development	FY 1982	FY 1983
Space Transportation System	3089.9	3597.8
Space Transportation Capability Development	2623.4 a/	2144.1 b/
Space Transportation Operations	466.5	1453.7
Space Science and Applications	896.2	1034.1
Physics and Astronomy	322.5	441.0
Life Sciences	39.5	55.7
Planetary Exploration	210.0	186.4
Space Applications	324.2	351.0
Technology Utilization	8.0	9.0
Aeronautical Research and Technology	264.8	280.0
Space Research and Technology	111.0	123.0
Space Tracking and Data Acquisition	402.1	498.9
Total Research and Development	4772.0	5542.8
Construction of Facilities	113.7	97.5
Research and Program Management	1134.4	1199.1 c/
TOTAL NASA	6020.1	6839.4

Note: These amounts are presented in the line item structure of the FY 1984 budget. The FY 1983 amounts are consistent with the Operating Plan transmitted to the Committees on November 18, 1982, except as noted.

a/ Reflects approved reprogramming of $15M from Space Transportation Capability Development to CoFF.
b/ Reflects reallocation of $17M from Space Transportation Capability Development (Upper Stage Ops) to Space Transportation Operations (Shuttle Ops) consistent with deferral action previously reported.
c/ Includes $30.2M proposed supplemental appropriation to partially cover cost of revised salary rates effective in FY 1983, the Agency's contribution to medicare and increased Agency costs for health insurance.

QUESTION 4:

Please provide a tabulation of projected total costs of all major programs included: (please include initial estimates for budgeted new starts).

a. original estimate date and amount
b. current estimate, and
c. NASA's estimate of what portion of any increased cost may be due to inflation.

ANSWER 4:

See the enclosed table.

QUESTION 5:

Please provide an analysis of the effect of inflation on the aggregate buying power of NASA. Please include a separate summary of the Space Shuttle program cost estimates and the effect of inflation on total cost at completion estimates.

ANSWER 5:

See the enclosed table.

QUESTION 6:

Please furnish, by major program, the unobligated balance of funds for FY 1982 and FY 1983 and the actual or estimated carry over as of January 15, 1983.

ANSWER 6:

See the enclosed table.

National Aeronautics and Space Administration
Estimated Total Project Cost
(In Millions of Dollars)

Table D

	Original Development Estimate		Current Estimated
	Date	Range	Range
Solar Maximum Mission (SMM)	4/77	75-90	75-90
Space Telescope (ST) Development	2/78	572-607 (a)	Under Review (a)
International Solar Polar Mission (ISPM) Dev.	1/83	120-140	120-140 (b)
ISPM Mission Ops. & Data Analysis	1/83	20-30	20-30 (b)
Gamma Ray Observatory (GRO) Development	1/83	395-435	395-435 (c)
GRO Mission Ops. & Data Analysis	1/83	30-40	30-40 (c)
Galileo Development	1/83	650-700	650-700 (d)
Galileo Mission Ops. & Data Analysis	1/83	180-210	180-210 (d)
Venus Radar Mapper (VRM) Mission Development	(e)	320-350 (e)	320-350 (e)
VRM Mission Ops. & Data Analysis		30-50 (e)	30-50 (e)
Landsat-D	1/79	330-350	500-510 (f)
Search & Rescue	11/79	20-24	20-24
Earth Radiation Budget Experiment (ERBE)	1/83	110-130	110-130 (g)
Advanced Communications Technology Satellite (ACTS) project	(e)	325-425 (e)	325-425 (e)
Tethered Satellite	(e)	40-50 (e)	40-50 (e)

(a) Original Space Telescope estimate was stated in FY 1978 budget dollars, to be updated annually. The current estimate is currently under review due to continuing development problems.

(b) The ISPM development estimate is established with the FY 1984 budget; the previous (planning) estimate was $190-230M for development and $40-50M for mission operations and data analysis. These estimates were decreased as a result of the cancellation of the U.S. spacecraft and associated experiments development. The ESA single ISPM spacecraft will be launched in 1986 via the Shuttle/Centaur Upper Stage. NASA will provide experiments to be flown on the ESA spacecraft, as well as launch and tracking support.

(c) The GRO development estimate is established with the FY 1984 budget; the previous (planning) estimate was $180-225M for development and $30-45M for mission operations and data analysis. These estimates were increased as a result of the launch being slipped from late 1985 to 1988, plus an increase in the estimated cost of both the spacecraft and the experiments based on further definition of requirements.

(d) The Galileo development estimate is established with the FY 1984 budget; the previous (planning) estimate was $275-295M for development and $150-170M for mission operations and data analysis. These estimates were increased as a result of the launch being slipped from 1982 to 1986. The Galileo orbiter and probe will be launched via the Shuttle/Centaur Upper Stage.

(e) Planning estimate; development estimate not yet available.

(f) The Landsat-D current estimate has been reduced from $500-550M estimate of last year, based on the successful launch of Landsat-4 in July 1982.

(g) The ERBE development estimate is established with the FY 1984 budget; the previous (planning) estimate was $70-85M. This estimate was increased as a result of a launch slip from 1982 to 1984, and a repricing of the project.

Note: Unless otherwise noted, cost estimates are expected to cover "normal" technical difficulties and cost escalation. In early years, for several of these projects, however, the inflation rate was substantially higher than anticipated, and while the precise impact on the project costs is not readily ascertainable, it is clear that not all the earlier cost projections were adequate to cover this additional burden.

Table G

National Aeronautics and Space Administration

Unobligated Balance
(millions of dollars)

Research and Development	FY 82 & Prior Unobligated Balance 9/30/82	FY 1983 Unobligated Balance as of 12/31/82	Estimated Unobligated Balance 9/30/83
Space Transportation Capability Development	135.2	1617.6	---
Space Transportation Operations	21.0	1086.3	---
Physics and Astronomy	43.3	337.8	---
Life Sciences	3.0	45.2	---
Planetary Exploration	22.3	154.3	---
Space Applications	46.6	284.8	---
Technology Utilization	1.2	7.8	---
Aeronautical Research and Technology	32.7	196.4	---
Space Research and Technology	8.4	95.7	---
Space Tracking and Data Acquisition	33.6	355.2	---
Total Research and Development	347.3	4181.1	---
Construction of Facilities	63.7	97.3	72.4
Research and Program Management	---	894.7 a/	---
TOTAL NASA	411.0	5173.1	72.4

All research and Development and Program Management funds are planned for obligation by the end of FY 1983. Historically, however, there remains a relatively small portion of the R&D funds in the procurement pipeline which is technically unobligated at the end of the fiscal year. This amount, statistically equivalent to a few weeks of procurement activity, is obligated in the next fiscal year. These amounts in the procurement pipeline have no impact on the following fiscal year requirements. For Construction of Facilities, it is estimated that $73.2 million of the FY 1983 appropriation of $97.5 million will be obligated in FY 1983, leaving a planned unobligated balance $24.3 million. In addition, $48.1 million of prior appropriations are estimated to be unobligated at the end of the year.

a/ Includes $30.2M from proposed supplemental appropriation to partially cover revised salary rates effective in FY 1983, the Agency's contribution to medicare and increased Agency costs for health insurance.

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Answer 5.

National Aeronautics and Space Administration

EFFECT OF INFLATION ON SHUTTLE DEVELOPMENT COSTS
(millions of dollars)

	Baseline Estimate FY 1971 Dollars	Current Estimate FY 1971 Dollars	Current Estimate Inflated Dollars	Impact of Inflation on Current Estimate
DDT&E Costs	$5,150	$6,746	$10,080	$3,334

Question 7:

Please provide a summary of the Space Transportation System nonrecurring cost estimates including the fiscal year 1983 budget estimate (1971 dollars and dollars of the fiscal year 1982 budget) and the fiscal year 1984 budget estimate (1971 dollars and dollars of the fiscal year 1984 budget) for the following:

1. Shuttle design, development, test, and evaluation;
2. Shuttle investment
3. NASA facilities
4. Western Test Range facilities; and
5. Additional investment to fly the 581 mission model (Expendable Launch Vehicle and modification and Upper Stage DDT&E and investment).

Answer 7:

See enclosed chart.

QUESTION 8:

Please provide a summary of the Space Shuttle production sub-line item including initial cost estimates, current cost estimates, all changes which have occurred and associated schedule changes.

ANSWER 8:

At the time of the Shuttle development commitment, the requirements to establish an operational orbiter fleet were projected at $1 billion in 1971 dollars. The Production budget was established primarily to provide for the modification or refurbishment of two orbiters (Orbiter 101 and 102) bought in the development phase and the procurement of three additional orbiters.

Since that original estimate, planning for the implementation of the orbiter fleet has been impacted by budget reductions, orbiter delivery schedule adjustments, revised estimates based on experiments in the development phase, and new requirements identified during the development test flight program. These include the FY 1977 budget decision to defer the start of production; schedule adjustments related to the Agency's realignment of program funding between DDT&E and Production in FY 1978 and FY 1979; the FY 1979 budget decision to delay proceeding with a fifth orbiter; the actual orbiter and main engine fabrication and assembly experience on development hardware; the delivery schedule stretchout included in the FY 1980 and FY 1981 budget plans; and the identification of new requirements, such as the orbiter weight reductions program and systems engineering support. Based on the combined effects of these varied impacts, the current estimate to establish the fleet of operational orbiters is $3.827 billion in real year dollars which is equivalent to $1.830 billion in 1971 dollars. This estimate provides for modifying Orbiter 102 in FY 1983 after its use for the orbital flight test program and early operational flights in order to support the first Spacelab mission, subsequent structural modification in FY 1985 to support full operational use, upgrading the orbiter structural test article to an orbital configuration (Orbiter 099), and the fabrication and assembly of two additional orbiters and associated main engines.

A comparison of the original and current production orbiter delivery schedules is a follows:

	Orbital Deliveries	
	Original Plan (3/72)	Current Plan
Orbiter 101 Modified	March 1979	—
Orbiter 099 (STA Modified)	—	July 1982 (Actual)
Orbiter 102 (Spacelab Mod)	—	July 1983
Orbiter 103	December 1978	September 1983
Orbiter 104	October 1979	December 1984
Orbiter 105	August 1980	—
Orbiter 102 Full Mod	December 1980	FY 1985

The current budget structure for Shuttle Production and Capability Development includes additional investment cost to the orbiter fleet investment. These elements, in real year economics, include ground support equipment for both the orbiter and the KSC second line of

facilities to support flight to flight vehicle processing estimated at $.656 billion; systems integration and support activities estimated at $1.302 billion; the procurement of an initial inventory of operational spares and equipment estimated at $1.993 billion, the provision of $.161 billion to accomodate the Centaur upper stage within the Shuttle system; completion of residual development, primarily for the main engine life growth program, estimated at $.796 billion and $.223 billion estiamted for the development of a filament wound case for the solid rocket booster to augment system performance. In addition, $.300 billion is included to provide for potential changes or systems modifications required as the result of flight experience or to increase reliability and safety of the operational system.

QUESTION 9:

Please provide a requirements and production cost analysis for a fifth orbiter based on initiating the production buy in FY 1983 and 1984 compared with FY 1986 including the implications of the loss of an orbiter, the implications of an orbiter being out of service for an extended period, and the implications regarding maintenance of the subcontractor base.

ANSWER 9:

Over the past year, NASA has intensely studied the need for additional orbiters with emphasis on the requirement for a fifth orbiter. This examination focused on impacts of the loss or extended downtime of one of the currently authorized four orbiter fleet and on the likelihood of projections of future growth being realized beyond the capabilities of the four orbiter fleet.

The results of the studies have shown that four orbiters can meet the mission manifest requirements for at least the remainder of this decade. However, a theme emerging from the studies was the need for a measure of assurance to accommodate unscheduled maintenance, system upgrades, aborts, and accidents causing extensive damage or loss of an orbiter.

The proposed orbiter structural spares will provide the assurance necessary for the Nation to operate the four orbiter fleet in a robust manner. The FY 1984 budget includes $100 million of a planned total of $420 million for the procurement of orbiter structural spares. These structural and component spares will provide the necessary assurance that Shuttle operations will continue in the face of minor problems, modifications, or other periods of extended orbiter outages.

Another important benefit to procuring the structural spares is the protection of our orbiter production capability. Following delivery of the OV-104 hardware, many structural and component subcontractors would otherwise be closing down their orbiter lines; this action preserves major areas of production capability for an additional 1-2 years, depending on the element.

An FY 1984 go-ahead for OV-105 would provide a late 1988 or early 1989 delivery at an estimated cost for the orbiter systems alone of about $1.8 billion. However, it should be recognized that there are further additional costs associated with the procurement of a fifth orbiter dependent on its eventual use and supporting system requirements and capabilities. Initiating procurement of a fifth orbiter in FY 1986 would slip the delivery, but with the production of these structural spares the lead time to procure an additional orbiter, if needed, would be reduced by about 1-2 years. The specific effect of the procurement of these structural spares on costs and schedules of a possible follow-on orbiter procurement have not been determined. Attached is a summary of the STS capability and projected firm missions. Also attached is a summary of the estimated costs for a fifth orbiter and for the structural spares.

OFFICE OF SPACE FLIGHT
STS NON-RECURRING COST ESTIMATES
(DOLLARS IN BILLIONS)

JMG 01/28/83

	FY 1983 BUDGET ESTIMATES		FY 1984 BUDGET ESTIMATES	
	DOLLARS OF FY 1983 BUDGET	1971 $ EQUIVALENT	DOLLARS OF FY 1984 BUDGET	1971 $ EQUIVALENT
SHUTTLE NON-RECURRING COSTS				
SHUTTLE DEVELOPMENT (DDT&E)	10.083	6.748	10.080	6.746
INITIAL FLEET INVESTMENT TO INCLUDE PROCUREMENT OF 2 ORBITERS AND THE MODIFICATION OF 2 ORBITERS BOUGHT IN DDT&E	3.794	1.834	3.827	1.830
INITIAL FACILITIES FOR DEVELOPMENT, TEST, MANUFACTURING PRODUCTION AND A LAUNCH CAPABILITY AT KSC	.466	.300	.482	.300
TOTAL NON-RECURRING COSTS	14.343	8.882	14.389	8.876
ADDITIONAL INVESTIMENTS TO FLY 581 MODEL				
*EXPENDABLE LAUNCH VEHICLES MODS FOR EARLY SHUTTLE FLIGHTS	.703	.355	1.019	.498
**FACILITIES AT WESTERN TEST RANGE	2.363	1.081	2.768	1.257
TOTAL ADDITIONAL INVESTMENTS	3.066	1.436	3.787	1.755
TOTAL OF ABOVE	17.409	10.318	18.176	10.631

*REPRESENTS NASA SSUS DEVELOPMENT, DOD DEVELOPMENT OF THE IUS AND NASA INVOLVEMENTS IN THE DEVELOPMENT OF NON-DOD UNIQUE IUS REQUIREMENTS, AND NASA AND DOD DEVELOPMENT OF CENTAUR FOR SHUTTLE.

**REPRESENTS UNOFFICIAL DOD ESTIMATES.

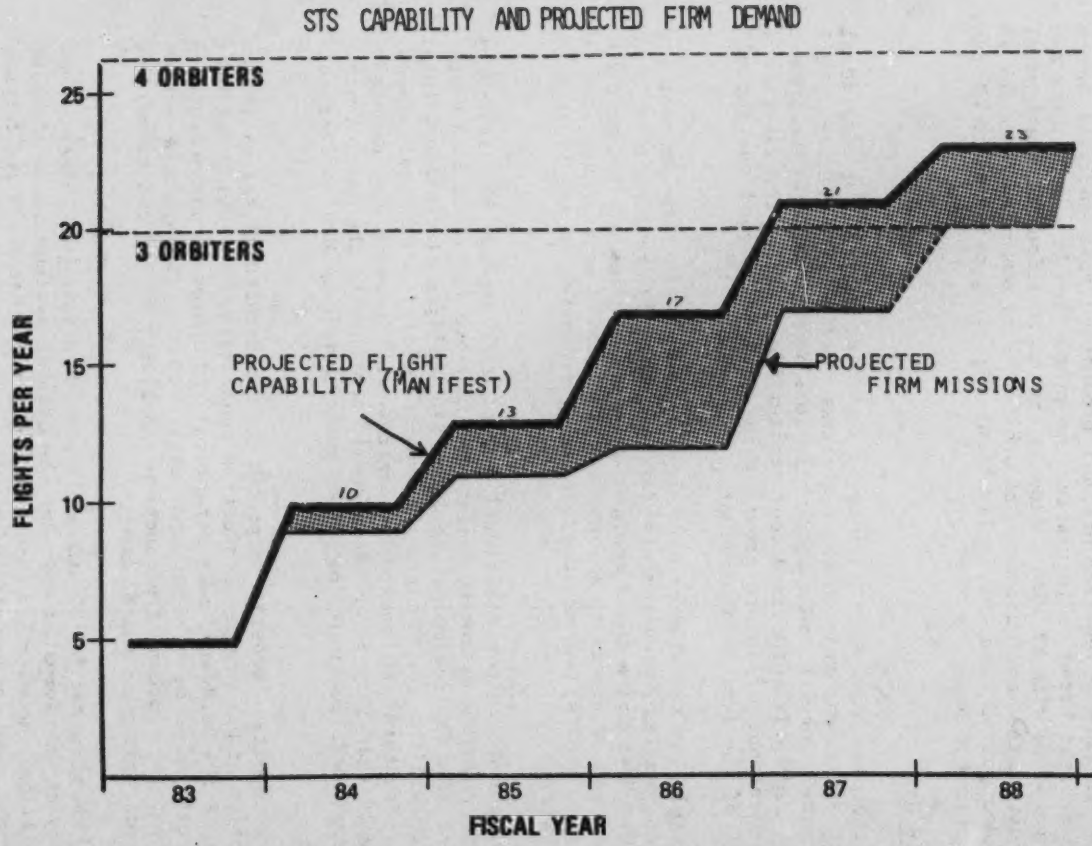
2/1/83

National Aeronautics and Space Administration

EFFECT OF INFLATION ON NASA BUDGET
COMPARATIVE PURCHASING POWER INDICES BY 1978 - 1984

	GNP Price Deflator (%)[1/]	NASA Aerospace Price Deflator (%)[2/]	Budget Outlays - Millions of Dollars Actuals	Constant FY 1983[3/]
FY 1973	100.0	100.0	3315	3315
FY 1984	92.0	93.3	3256	3038
FY 1975	84.2	84.2	3267	2297
FY 1976	80.0	77.2	3669	2832
FY 1977	75.6	69.7	3945	2750
FY 1978	70.5	64.7	3983	2577
FY 1979	65.0	59.1	4197	2480
FY 1980	59.6	53.4	4850	2590
FY 1981	54.5	48.2	5426	2615
FY 1982[4/]	51.4	44.0	6035	2655
FY 1983[4/]	48.9	40.9	6724	2750
FY 1984[4/]	46.2	38.2	6981	2667

1/ Economic Indicators, December 1982, year over year growth.
2/ Reflects labor intensive nature of NASA purchases using aerospace forward pricing rate data.
3/ Constant FY 1983 outlays calculated using the NASA Aerospace Price Deflator.
4/ Current estimates.


STS CAPABILITY AND PROJECTED FIRM DEMAND
4 ORBITERS
3 ORBITERS
25
20
15
10
5
FLIGHTS PER YEAR
PROJECTED FLIGHT
CAPABILITY (MANIFEST)
PROJECTED
FIRM MISSIONS
10
13
17
21
23
83
84
85
86
87
88
FISCAL YEAR
OP-82-0113
11/18/82

FUNDING REQUEST FOR FIFTH ORBITER AND STRUCTURAL SPARES

FUNDING INCLUDED IN THE NASA REQUEST TO OMB FOR A FIFTH ORBITER (9/15/82)

1983	1984	1985	1986	1987	1988	1989	TOTAL*
20	200	340	390	410	375	65	1800

*FUNDING IN REAL-YEAR DOLLARS, BASED ON A DELIVERY IN SEPTEMBER 1988

FUNDING FOR STRUCTURAL SPARES IN BUDGET REQUEST TO CONGRESS

1983	1984	1985	1986	1987	TOTAL
20	100	120	120	60	420

QUESTION 10:

In accordance with Rule XI, Clause 2(1)(4) of the Rules of the House of Representatives, the Committee is required to include in the report accompanying the NASA authorization bill an assessment of the impact of the legislation on inflation. Please provide the Committee with any information or reports which would be useful to the Committee in fulfilling this requirement.

ANSWER:

Effect of Legislation on Inflation:

In accordance with Rule XI, Clause 2(1)(4) of the Rules of the House of Representatives this legislation is assessed to have no adverse long-run inflationary effects on prices and cost in the operation of the national economy. NASA expenditures are labor intensive, with approximately 85 percent of spending directly for jobs and the remainder for materials. NASA employs about 21,000 civil servants and supports about 109,000 contractor employees, plus about 4,300 support services contractors. Assuming a multipler effect 2.5, the total, short-run employment effect on the United States' economy is about 336,000 jobs. This represents less than one-half of one percent of the total civilian labor force in the United States---too small to have a significant national effect, although there could be some specific cases of industrial and regional employment and price changes influenced by NASA expenditures.

The most significant economic effects of NASA spending are the long-run producivity advances from new technologies developed for the space and aeronautics programs. Many NASA-sponsored advances in air and space and transportation, communications satellites, remote sensing satellites, and other innovations have improved the productive capacity of industry and stimulated the development and growth of many new businesses. These expanded business opportunities have and are expected to continue to stimulate more productive, non-inflationary private sector economic growth and job creation.

Although it is difficult to assess the results of the various macro-economic studies of the effects of NASA spending on the GNP, it is generally believed from the analyses done by the Midwest Research Institute, Mathematica, Inc., and others, that NASA high technology R&D expenditures have returned more to the economy in substantial and long-lasting productivity gains than has been spent. Since these gains are through spinoff commercial advances, they are "extra" returns above and beyond the primary goal of NASA programs: the successful completion of the various R&D mission assignments to meet public sector needs. Therefore, any gains which show positive economic returns in the long run indicate a non-inflationary, significant return to the citizens of the United States.

RESPONSES TO QUESTIONS FROM CHAIRMAN FLIPPO ON FY 1984 CONGRESSIONAL BUDGET

QUESTION 1:

Please provide historical trend data (FY 1978 through FY 1984) showing the number of trips taken and planned in three travel categories. Data should be normalized to end-of-year FY 1983 professional personnel ceiling.

ANSWER 1:

The historical trend normalized to end-of-year FY 1983 professional personnel ceiling is provided below:

	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84
Normalized Trips:							
Program Travel	34,669	35,129	33,697	29,771	32,440	34,650	34,472
Management & Operations Travel	6,511	5,875	5,479	5,609	6,740	6,550	6,516
Scientific & Technical Development Travel	3,548	3,639	3,086	2,634	3,632	3,500	3,482
Normalized Total	44,728	44,643	42,262	38,014	42,812	44,700	44,470
Total Actual Trips	47,273	46,447	44,101	38,778	43,037	44,700	44,700

QUESTION 2:

What is the amount, by agency, expected in FY 1983 and FY 1984 from other agencies and commercial customers to reimburse NASA for the salaries and benefits of civil service employees? How many employees do these funds cover?

ANSWER 2:

Listed below are the dollars expected in FY 1983 and FY 1984 from other agencies and commercial customers to reimburse NASA for the salaries and benefits of civil service employees, and the number of workyears covered.

Agency	FY 1983		FY 1984	
	Amount ($ in Thousands)	Workyears	Amount ($ in Thousands)	Workyears
Department of Energy	1,701	40	---	---
Department of Commerce	3,120	61	4,348	85
Department of Defense	1,012	24	1,307	31
Other Government agencies	50	1	50	1
Non-Federal Sources	5,767	178	5,896	182
Total	11,650	304	11,601	299

QUESTION 3:

Please provide trend data (FY 1980 through FY 1984) showing utility usage (BTU's) and total costs.

ANSWER 3:

The R&PM utility energy usage (Source BTU's) and the R&PM total utility costs are as follows:

	FY 80	FY 81	FY 82	FY 83	FY 84
BTU's (10^{12}) (Source)	15.5	14.5	14.7	14.7	15.0
Costs in Millions	55.4	63.4	67.5	82.5	91.7

QUESTION 4:

What is the number and cost, by Center, of reimbursable detailees and R&D funded post-graduate fellows for FY 1983 and FY 1984.

ANSWER 4:

	Reimbursable Detailees				Post-Graduate Fellows			
	1983		1984		1983		1984	
Installation	Wkyr	$	Wkyr	$	Wkyr	$	Wkyr	$
ARC	8	311	7	291	58	2,030	58	2,050
GSFC	—	—	—	—	52	1,820	52	1,838
HQ	18	771	14	599	—	—	—	—
JSC	68	3,304	70	3,400	10	350	10	354
KSC	1	49	1	49	—	—	—	—
LaRC	—	—	—	—	21	735	21	742
LeRC	—	—	—	—	23	805	23	813
MSFC	—	—	—	—	14	490	14	495
NSTL	—	—	—	—	—	—	—	—
NASA TOTAL	95	4,435	92	4,339	178	6,230	178	6,292
				JPL	23	805	23	813
				TOTAL	201	7,035	201	7,105

QUESTION 5:

What is the baseline number, by center, of R&PM support contractors in FY 1983 and FY 1984? What are the costs associated with the total number of SSC in FY 1983 and FY 1984?

ANSWER 5:

The baseline values for R&PM support contractors for FY 1983 and FY 1984 are shown by Center in the table below:

	FY 83 Est	FY 84 Est
ARC	267	267
GSFC	428	428
HQ	354	354
JSC	774	798
KSC	1,442	1,442
LaRC	281	281
LeRC	214	214
MSFC	532	532
NSTL	13	21
NASA TOTAL	4,305	4,337

The costs associated with these support service contractors are $134.6 million for FY 1983 and $142.5 million for FY 1984.

QUESTION 6:

How much is included in FY 1983 and FY 1984 for lease, purchase, maintenance and operations of ADP equipment?

ANSWER 6:

The FY 1984 R&PM budget estimate provides for the following:

	FY 1983	FY 1984
	(Dollars in Thousands)	
ADP Equipment	6,425	6,524
ADP Operations	22,648	26,455
TOTAL	29,073	32,979

QUESTION 7:

For FY 1983 and FY 1984, what is the cost of rental of land and property? How much space is leased?

ANSWER 7:

The R&PM FY 1984 budget estimate provides for the following:

	FY 1983	FY 1984
Total Costs ($ in thousands)	8,345	9,063
(Rental from GSA)*	(7,844)	(8,480)
Total Space Leased (sq. ft.)	593,062	592,342
(Rental from GSA)*	(575,976)	(575,976)

*Includes Standard Level User Changes (SLUC) paid to GSA mainly for NASA Headquarters use of Federal office buildings in the District of Columbia.

QUESTION 8:

How much is included in FY 1983 and FY 1984 for rental of passenger vehicles (except GSA), GSA passenger vehicles, movement of goods and administrative aircraft operations. How many vehicles are covered by these funds? Also, show dollar amounts for and number of vehicles provided to contractors.

ANSWER 8:

	Total	
	1983	1984
Rental of Passenger Vehicles (Except GSA)	102	102
Rental of GSA Passenger Vehicles	1,347	1,684
Movement of Goods	2,388	2,556
Administrative Aircraft Operations	6,436	7,044
Number of Vehicles Covered	213	232
(Contractor)	(2)	(21)

QUESTION 9:

Summarize the results of the NASA EEO recruitment program over the past year.

ANSWER 9:

The information requested is as follows:

Overall: During FY 1982, the further reduction in the NASA workforce resulted in fewer hiring opportunities. Minorities in non-professional positions decreased in number but increased in percent. Minorities and women in professional positions increased on both numbers and percent.

	1981	Δ	1982
Total Population	21,844	-658 (-3.0%)	21,186
Minorities	2,472	-39	2,433
(%) of total population	(11.3%)		(11.5%)
Women	4,711	-91	4,620
(%) of total population	(21.6%)		(21.8%)

Professionals: 15.5% of professional hires were minorities.
22.2% of professional hires were non-minority women.

Over the last year, the percentage of minority professionals in the workforce increased from 8.4 percent to 8.7 percent. The percentage of non-minority women increased from 9.6 percent to 10.0 percent.

Non-Professionals: 26.9 percent of non-professional hires were minorities.

Over the last year, the percentage of minority non-professionals rose from 16.9 percent to 17.1 percent although they decreased in number from 1,254 to 1,196.

QUESTION 10:

What are the costs, by center, of both DTMS and IMS for FY 1983 and FY 1984.

ANSWER 10:

	DTMS		IMS	
Installation	1983	1984	1983	1984
ARC	---	---	10.1	12.4
GSFC	---	---	26.8	28.9
HQ	.3	.8	---	---
JSC	48.4	65.2	33.8	36.8
KSC	2.8	2.8	---	---
LaRC	---	---	20.6	22.2
LeRC	---	---	14.1	15.0
MSFC	13.8	18.2	15.2	20.1
NSTL	5.0	6.1	---	---
TOTAL	70.3	93.1	120.6	135.4

QUESTION 11:

Please provide a by-center report of progress against the 50% utility usage savings goal. Also describe further actions to be taken and expected savings.

ANSWER 11:

The progress of each NASA field installation against the 50 percent utility savings goal is as follows:

Field Installation	% Reduction From FY 1973 Actuals Through FY 1982
Ames Research Center	39
Downey Industrial Plant	15
ARC/Dryden Flight Research Facility	+30
Goddard Space Flight Center	30
Jet Propulaion Laboratory	39
Johnson Space Center	43
Kennedy Space Center	37
Langley Research Center	42
Lewis Research Center	37
Marshall Space Flight Center	52
Michoud Assembly Facility	23
National Space Technology Laboratories	45
GSFC/Wallops Flight Center	35
Others	60
NASA Total	38

QUESTION 12:

Please provide data showing escalation rates for support contractors services.

ANSWER 12:

The escalation rates projected for support contractor services are shown in the table below:

	FY 1982 to FY 1983 % Change	FY 1983 to FY 1984 % Change
ARC	8.9	5.0
GSFC	6.9	5.0
HQ	5.6	5.6
JSC	9.3	6.9
KSC	8.3	3.8
LaRC	14.0	5.0
LeRC	9.1	5.0
MSFC	10.1	6.5
TOTAL NASA	8.4	5.0

QUESTION 13:

Summarize the results of the latest round of SES bonuses.

ANSWER 13:

In 1982, NASA, in accordance with the Office of Personnel Management's guidance, awarded bonuses to 20% of its SES career employees. This percentage equated to 84 of our 422 eligibles receining bonuses. A breakdown of the 84 bonuses is as follows:

Number of Bonuses	Amount of Bonuses
4	$11,130
4	11,115
13	9,360
62	6,435
1	6,023

QUESTION 14:

Summarize the results of the most recent year under "merit pay".

ANSWER 14:

On October 3, 1982, 2,837 grade 13-15 managers and supervisors received their second Merit Pay increase. Merit Pay increases, including one-half of the 4 percent comparability raise effective in October 1982, during the second year of the program ranged from 2 percent of salary for those rated less than successful to 9.9 percent of salary for those performing in an outstanding manner.

The second year of Merit Pay was significantly improved over the first year. In the first year, last minute changes ordered by the Comptroller General and the Office of Personnel Management resulted in severe reductions of the anticipated payout. This had caused morale problems among the middle managers. The availability to distribute a reasonable payout in the second year is believed to have relieved the morale problem to a great extent.

QUESTION 15:

Please provide a current listing of re-hired annuitants.

ANSWER 15:

The following is a list of former NASA employees currently employed as re-employed annuitants (excludes experts, consultants, and other intermittent appointments):

Re-employed Annuitants as of 2/1/83

	Perm.	Temp.	Total
ARC	1	6	7
GSFC	--	--	--
HQ	2	--	2
JSC	--	--	--
KSC	--	1	1
LaRC	--	--	--
LeRC	--	--	--
MSFC	--	--	--
TOTAL	3	7	10

PERMANENT

ARC — Giovannetti, Angelo - SES
Chief Engineer, Staff of the Director

HQ — Coy, Edward F. - NASA Excepted
Executive Officer

Jefferson, Dorothy M. - GS-12
Secretary to Administrator

TEMPORARY

ARC — Lynn, Robert A. - GS-9
Construction Representative, Part-time

King, J. L. - WG-11
Sheet Metal Mechanic

Briggs, Lester - GS-14
Management Specialist

Tunnell, Phillips J. - GS-14
AST Technical Management, Part-time

Saltzman, Edwin J. - GS-14
Aerospace Engineer, Part-time

Ruby-Malone, Ruth T. - GS-6
Personnel Clerk, Part-time

KSC — Yasaki, Paul T. - GS-13
Aerospace Engineer

AEROSPACE SAFETY ADVISORY PANEL

ANNUAL REPORT

TO THE

NASA ADMINISTRATOR

JANUARY 1983

INTRODUCTION AND SUMMARY

The activities of the Aerospace Safety Advsiory Panel (ASAP) accelerated in 1982 to support the increased flight rate of the Space Transportation System (STS) and the assessment of data being acquired on the actual flight experience with the various subsystems. Approximately forty meetings took place involving NASA personnel, NASA contractors and members of the ASAP. The meetings included visits to all NASA centers directly involved in the flight hardware and its launching and testing, as well as contractor facilities. Appendix I contains a list of visits for 1982 along with subjects covered during both the individual visits and the complete Panel discussions.

During the year the Panel membership was augmented by the appointment of Gerald W. Elverum, Jr., Vice President and General Manager of the Applied Technology Division of the TRW Space and Technology Group. The purpose of this appointment was to augment the Panel's knowledge of propulsion systems needed because of Dr. Seymour C. Himmel's completion of his six-year term and the signal importance of these systems to Shuttle and payload safety. Because of Dr. Himmel's familiarity with the entire Shuttle development, he has been retained as a consultant.

In addition to Gerald Elverum's appointment, the Panel has added Robert D. Rothi, Chief Design Engineer of the Douglas Aircraft Company as a consultant to follow the progress of essential STS systems, landing gear, flight controls, power and other auxiliary systems as flight experience is obtained. It is the plan to appoint Robert Rothi to the ASAP as a member when a position becomes available in the statutory number of members due to normal completion of terms. The total membership of the Panel is listed in Appendix II.

This year's Panel report will be based upon newly analyzed information from flights STS-1, and STS-2 in 1981, and the more current information from STS-3, -4, and -5. In addition, we have reviewed the status of R&D aircraft and administrative aircraft flight safety procedures and administration for support, test, and training flights utilizing NASA's fleet of aircraft based at the several centers.

The Panel continued with its study of NASA's plans and improvements to increase the flight rate of the Shuttle, improve the logistics and reduce the turn-around costs.

NASA staff activities supporting the needs of the ASAP, the gathering of data, the scheduling of fact-finding for the members and the alert reporting of changes, test results, organization changes, and NASA schedules have been exceptionally well handled during 1982, and the Panel appreciates this excellent support.

As a result of its work the Panel has the following conclusions and recommendations to make:

CONCLUSION 1

The Shuttle has been successful as a developmental vehicle but the flight test series has been too short to completely explore the design performance envelope.

RECOMMENDATION 1

A formal program should be implemented to identify flight test objectives compatible with each Shuttle mission flown so that the entire flight envelope will be defined in a timely manner.

CONCLUSION 2

The determination of the performance envelope of the Shuttle includes a determination of the loads that the vehicle experiences in flight. Before this determination is complete, there have been parallel efforts to reduce actual factors of safety in order to reduce weight. This reduction must proceed cautiously until the structural loads and capability are confirmed.

RECOMMENDATION 2

The Panel recommends that extreme caution be used in decreasing structural factors of safety for weight purposes before all the pertinent flight variations are explored and all relevant data has been analyzed and taken into account. A corollary recommendation is that the Modular Auxiliary Data System (MADS) instrumentation package be carried until the flight limits are determined.

CONCLUSION 3

The Shuttle and its operation is not an airline, even though the airline approach to solving problems such as logistics may well apply. The literal application of the detailed solution of airline problems can be misleading when applied to Shuttle situations. Nevertheless, Shuttle "operations" will be sufficiently different from R&D flying to justify a major operational organization which concentrates on the reduction of turn-around time, cost, and operational safety. The R&D community should respond to the operators of the STS on a demand (contract) basis.

RECOMMENDATION 3

The NASA should identify a single, responsible operational logistics organization, properly staffed, that should determine what commercial methodology is useful to the Shuttle and then determine the extent to which those methods are applied to Shuttle problems.

CONCLUSION 4

Shuttle operation will require a major sustaining engineering effort by the present NASA centers and contractors, particularly until the operational capability is defined and implemented. This should not be confused with, or funded as R&D.

RECOMMENDATION 4

In order to control operational economics, the Panel recommends that the sustaining engineering should be the responsibility of, and be budgeted by, the operational organization, regardless of where and who does the work.

CONCLUSION 5

The pressure of schedules seems to have relaxed the rigor of the certification process as applied to changes.

RECOMMENDATION 5

In the past, the certification of the Shuttle involved many test considerations and reviews. The current and future changes in the Shuttle must have the same rigor of certification. The policy and standards should be established by an independent organization within NASA, e.g, the Chief Engineer, and should

have the direct sponsorship of the Administrator. FAA processes and practices may provide a model. Such a program if it is a function of the NASA chief engineer, would also be independent of any future operations organization and, thus, it would be in a position to certify operational procedure and practices. Such a procedure would also simplify the Panel's problem of being informed of changes in a timely manner.

CONCLUSION 6

The aerodynamic flight stability of the Shuttle is exceedingly important in the landing phases. To the extent that this maneuver is a combination of the ship's very critical stability characteristics, the pilot's perception of control needs, and the computer's logic, it is a deceptively simple thing with little room for error. The apparent panacea of switching to the present autoland system should be cautiously explored. It is also important to give the pilot every tool available to enhance his perception of the craft's performance. The heads-up display is in this category and is useful both in the manual as well as in monitoring autoland performance.

RECOMMENDATION 6

The Panel recommends that autoland be tried at the earliest opportunity where there is a "repeat" pilot who has previously made a manual Shuttle landing. This dual experience will be invaluable in assessing manual vs. automatic operation. It is also recommended that the total installation of the heads-up display be expedited and be operational for this demonstration.

CONCLUSION 7

Substantial redesign of the SSME turbomachinery is required for the desired engine life at the outputs needed by proposed future payloads.

RECOMMENDATION 7

The Panel recommends the design of new replacement turbomachinery for the SSME that will achieve current required mission life at the full power level. If possible without compromising the achievement of these objectives provisions might be incorporated for future growth. In addition to the procurement of adequate numbers of the current turbomachinery elements, the interim need for spares created by the short life of the current machines at high output must be met.

CONCLUSION 8

The Panel feels that the landing gear tires and brakes have proven to be marginal and constitute a possible hazard to the Shuttle.

RECOMMENDATION 8

A study of a gear redesign should be started that will achieve an adequate factor of safety with the maximum proposed Shuttle loads. It seems to the Panel that such an effort should include an investigation of changing the attitude of the Orbiter on its gear. Reducing the nose-down attitude would substantially reduce wheel loads during rollout and braking.

FLIGHT SYSTEMS EXPERIENCE THROUGH 1982

The ASAP, in following the results of current flight data commend both the development teams at the centers and the operational teams which launched, conducted the mission and retrieved the Orbiter and its crews. The ASAP particularly tracked the performance of the internal power systems, control systems, and the thermal protection systems, all of which had concerned the Panel in the initial development phases of the program. It is encouraging to report that all of these systems appear to be performing well.

The Panel has continuing concern regarding the progress in flight control development, the confirmation of structural integrity, the achievements of operational ratings of the main engines, and the transition of the entire system to operational status in the absence of complete flight confirmation of the Shuttle element performance. These specific areas of concentration for the ASAP are in the following sections.

FLIGHT CONTROL PERFORMANCE

The Demonstration of Autoland Systems

The Aerospace Safety Advisory Panel recommends that NASA Headquarters assure the completion of the remaining simulations and tests of the Orbiter Autoland system, including touchdown and rollouts, and, if successful, encourage the earliest use thereof.

We believe that safety will be enhanced if the approach and landing conditions of airspeed, angle of attack, sink speed, and touchdown point can be optimized by automatic control. The experience that suggest this emphasis includes:

a. Studies of Shuttle landings to date show that tire,

wheel, and brake stresses are approaching limits.

b. Short runways, with inadequate overruns, are a cause for concern, for instance, a transAtlantic abort to Dakar.

c. Landing with excess speed increases stresses, as well as exposing the Orbiter to a "weight on wheels" instability that is divergent, as in most delta-wing aircraft.

Problems in pitch control of the Orbiter have been observed since the Pilot Induced Oscillations (PIO) of the fifth Approach and Landing Test (ALT 5). Some improvements can be made in software and mechanical controls, but correction of the basic characteristics would require complete redesign; perhaps including canard control surfaces.

A skilled pilot, under non-stressful conditions, can "grease" the Orbiter onto the runway; witness some of the beautiful landings to date. This requires great precision in establishing approach conditions, and the avoidance of any sudden inputs to pitch control. Aborts, heavy payload landings, less skilled pilots - all bias conditions toward the limits in control and mechanical capability.

An autoland landing takes the uncertain "gain" of the pilot out of the loop. The precision and resolution of the Inertial Measuring Units and the integrating rate gyros combined with Microwave Scanning Beam Landing System (MSBLS) and the digital autopilot allows the main computers to control attitude, airspeed, and sink rate to a precision that few humans can match except under ideal conditions.

As to reliability:

a. Automatic landings have been in use in commercial aircraft operations for about 10 years.

b. Elements of the autoland system have been used on every Shuttle flight excluding final glide slopes and landing.

c. Dozens of Shuttle training aircraft flights have used the MSBLS at KSC (down to about 20 feet above the runway).

In attempting to promote demonstration of the autoland system, the ASAP recognizes these factors as valid:

a. Astronauts, by virtue of years of training and simulation experience in the manual control process, are understandably reluctant to "let a machine do it."

b. Monitoring progress of the autoland system is difficult without a heads-up display or other device to assist in judging progress and eases take-over in the event of system failure.

Nevertheless, the ASAP urges such a demonstration and suggests the following:

1. A demonstration of the autoland system should be scheduled for a repeat commander or pilot as soon as the heads-up display is useable.

2. NASA should reexamine the auto braking and autolanding gear extension systems to make the autolanding system complete.

3. Provisions for autoland should be installed at the most likely contingency landing sites, e.g. Dakar.

4. The investigations of ground control de-orbit should be revisited for possible rescue via automatic de-orbit and remote or automatic control to autoland.

STRUCTURAL INTEGRITY

During the year 1982, the ASAP has given particular attention to the safety aspect of the following structural areas:

- o Lightweight external tank
- o Use of instrumented flight data
- o Continued expansion of structural operating limits
- o Structural modification of OV-102
- o Filament wound motor cases for solid rocket boosters

Filament Wound Case for Solid Rocket Boosters

The ASAP reviewed the structural aspects of the Filament Wound Case (FWC) at MSFC on June 10. The Panel's impression based on this limited review is that the plans for design, development, and testing are well thought out and that the structural integrity of the final product will be solidly based on test data. The minimum flight design factor of safety (F.S.) is 1.4. At the pinned joints between composite and steel, a F.S.-2.0 is used with "A" allowables* based on test data.

Light Weight External Tank (LWT)

The specification for the original external tank, now called Heavy Weight or Standard Tank (HWT), stated that the total inert weight be not greater than 77,902 pounds. The actual inert weight of the production HWT is 75,900 pounds, of which 57,195 pounds is structure.

*"A" allowables refers to material properties (e.g., tensile and compressive strength) equal to 99% or more of the population of measured values with a confidence level of 95%.

As a weight reduction measure, the external tank has now been redesigned and the new light weight tank has an actual inert weight of 66,800 pounds, of which 52,589 pounds is structure; so in going from the heavy to the light the structural weight was reduced by 4,600 pounds or 8.0 percent. The remainder of the 10,400 pounds, sometime reported as weight reduction from the original specification, took place in such nonstructural items as plumbing, thermal protection provisions, and updating the weight bookkeeping to account for the fact that the production HWT was 2,000 pounds underweight. Panel interest was focused on the structural integrity of the LWT.

In its review of the LWT the ASAP has centered its attention on the liquid hydrogen (LH_2) section for the following reasons (further discussion is found in Appendix III):

- The structural weight of the LH_2 tank of the LWT was reduced by 10.5 percent from that of the HWT.

- A critical design condition for the external tank is at staging of the Solid Rocket Boosters (SRB). In the absence of the SRB thrust, most of the 1.5M pounds total thrust of the Orbiter's three main engines is transmitted from the Orbiter to the aft end of the LH_2 tank and passes upward through the LH_2 tank to the liquid oxygen (LOX) tank, which is the major mass of the stack at that time. The thrust loading produces an axial compression and an overall bending due to the eccentricity of the thrustload, both of which produce compressive stresses in the LH_2 tank shell facing the Orbiter. The most probable failure mode is an instability, or buckling, of the LH_2 tank shell which could lead to serious consequences.

- The buckling strength of the LH_2 section of the LWT has been verified by test only to limit load (i.e., 109% of rated power level of the main engines) so that any margin

of safety between actual operating conditions and failing conditions is dependent solely on analytical procedures.

- Analytical procedures for prediction of shell instabilities are complex and not well correlated with experimental results, particularly for concentrated loads imposed on a complex nonuniform stiffened shell such as the LH_2 tank.

- The analyses that had been done were linear bifurcation types (STAGS and BOSOR).

The ASAP was concerned about the structural integrity of the Light Weight External Tank because:

- Data on strength justification has been sparse.
- Reluctance to depend entirely on linear analytical methods to predict failing instability of a complex shell-like structure subjected to concentrated loads as in the LH_2 tank when the design factor of safety is as low as 1.265.

The maximum thrust of the main Orbiter engines to be used during STS-6 is 104% of rated power level. This provides a test-proven F.S. of 1.14 (i.e., 1.19 FS @ RPL/1.04 RPL) for this flight. Concern within ASAP over this narrow margin resulted in a meeting which is reported in Appendix III among NASA personnel, technical members of the Martin-Marietta Corporation, with ASAP members at which views concerning the adequacy of analysis were expressed by two independent consultants in analytical methods for shell structures. The following recommendation resulted from this meeting: The ASAP accepts the adequacy of the current analysis and tests for the next Shuttle operation, but recommends that the nonlinear analysis now planned be performed to add further confirmation of the structrual adequacy of the Light Weight Tank (LWT) before flights using 109% of rated power level are approved. We understand this work is now underway.

Use of Instrumented Flight Data

The first five Shuttle flights have produced a substanital amount of instrumented flight measurements that are of extreme importance to safety exploiting the full structural capability of the STS. To realize the latent benefits of these flight data, it needs to be reduced to a readily useable form and then analyzed by stress analysts familiar with the structural arrangement, the design loading conditions, the analytical and experimental internal load determinations, and the failing stress allowables.

Continued Expansion of Structual Operating Limits

The instrumented flight data already collected during the missions of STS-1 through STS-5, properly analyzed, will provide a valuable data base to aid in predicting the safe magnitude of steps that can be taken in exploring beyond the boundaries established by the first five flights. The Development Flight Instrumentation (DFI) package used on the first five flights had the capacity to measure and record information from 4,000 sensors (strain gauges, thermocouples, pressure transducers, etc.). Because the DFI occupied a good portion of the payload bay and weighed about 11,000 pounds, it had to be removed from OV-102 after STS-5 to make room and payload available for Spacelab 1. There are no plans to use the DFI package on any future STS missions. To safely explore and establish the structural limits needed to utilize the full capability of the STS-5, some flight instrumentation to monitor critical strength items will be required.

Some of the issues involved in expanding the structural limits are:

- o Ascent and entry loads
- o Payload/Orbiter dynamic interaction
- o Ascent aerodynamic loads distribution
- o Structural thermal stresses versus cross range

It appears that the vehicle best suited to carry the brunt of the structural limits expansion is OV-102 after it has been through the Maxi-Mod process and has been equipped with a Modular Auxiliary Data System (MADS).1/ Thus modified and equipped, OV-102 will have full strength and adequate instrumentation to safely expand the structural operating envelope.

Structural Modification of OV-102

OV-102, as it flew the STS-1 through STS-5 missions, had unexpected structural limitations brought about by weight growth and early loads later found in need of correction. Discrepancies were dispositioned for the operational flight tests (OFT) and performance placards were issued on maneuver load factor (2g) and landing sink rate (6 fps). In addition, top sun conditioning was required prior to entry to relieve thermal stresses.

The ASAP understands that present plans are to use OV-102 to fly the STS-9 mission. The landing gross weight for STS-9 will be about 222,000 pounds which compares to the maximum previous landing weight of 209,483 pounds (STS-4). Also, the

1/The MADS planned for OV-102 will have the capability to record data from 855 sensors, of which about 500 are allocated to structures-related measurements.

load carried as cargo will be somewhat over 35,000 pounds which exceeds the previous maximum of 32,279 pounds (STS-5). Therefore, the STS-9 flight will need to be made with more restrictive flight limits than STS-1 through STS-5 in order to maintain the same margins of safety. In order to maintain the margin of safety of 1.4 in an abort-once-around, the maneuvering load factor, n_z, would be restricted to 1.4g and the sink rate on landing would be restricted to about 4.5 fps. The Panel believes that, with special training and special precautions, the tighter restrictions required for STS-9 can be safely flown, albeit at some higher level of risk than with a full strength vehicle.

The ASAP recommends that serious consideration be given to incorporating the Maxi-Mod modification into OV-102 following the STS-9 mission and also installing the planned data system (MADS), so that a full strength vehicle with adequate instrumentation can be used to continue the expansion of the operating envelope to the safe limits of the fleet vehicle.

ORBITER LANDING GEAR

The landing gear including wheels, tires, and brakes, is vital for the safe completion of any mission. With the future flights going to higher weights and lower margins, possibly even negative margins, it is imperative that existing capabilities be fully explored, documented and improved where necessary.

Of particular concern are the following:

o The inclusion of HUD or Autoland to consistently minimize the touchdown speed and distance from the runway threshold and to assure the optimum vehicle attitude to preclude PIO's and high ground loads.

o The inclusion of an Autobrake system to relieve the work

load on the pilot during a high strain period and to assure a uniform maximum brake pressure available to achieve the desired stopping distance.

o The high torque peaking of the carbon lining and the low strength of the beryllium stator and rotor keyways. The combination of materials should be reviewed as well as the means of attaching the brake to the axle. Excessive axle deflections under the abnormally severe tire loads induced by the negative angle of attack at high ground speeds dictate some type of floating mount to prevent the brakes from carrying ground loads in addition to the normal braking loads.

o The abnormally severe loads imposed on the main tires due to the 3.92^{o} negative angle of attack with the nose tire on the ground at high speeds. At 240,000 pounds with aft c.g., the static load on each main tire is only 54,000 pounds; whereas, at 165 knots the tire load increases to 140,000 pounds. Not only does this require stronger tires, but also higher inflation pressures, over 315 psi, to keep the tire defletions and carcass temperatures within limits. As tire pressures and ground speeds increase, the attainable coefficient of friction between the tire and the runway decreases thus increasing the stopping distance. A longer nose gear would help reduce the negative angel of attack and the main gear loads. Or it might even be possible to replace the dual main wheels with four wheel bogies to reduce the load per tire.

o The foreign-object damage to the thermally protected Shuttle surface by debris thrown up by the tires was mentioned in last year's report. When the landing performance has been improved to the point of using the paved runways, this issue will be resolved. Being able to use the paved runways available for normal landing and for emergency aborts is essential for continuing safe operations.

LITHIUM BATTERIES

The Panel was asked to assess the safety of the use of lithium-bromine complex batteries just prior to the launch of STS-5. The batteries in question were small A-A size cells for use in hand-held radios; D size cells in the cassette data recorders, space suit lights, TV cameras and the survival radio. An investigation revealed that the internal cell and battery hazards were acceptable and the Panel agreed that no changes should be made prior to STS-5, since the batteries were already on hand if not on board.

Lithium batteries have a large advantage in energy storage capability over standard batteries but their characteristics in many operational modes are not fully understood and accidents may occur if operating limits are exceeded and quality assurance is not assiduously controlled in their manufacture. Protection is provided to control the hazards. However, there are undoubtedly certain applications that are not practical with any other battery. In those cases, they should be used with suitable precautions. It is not so clear why the hazard would be acceptable in a flashlight or hand-held radio application. In making such a judgment, one should weigh all the factors such as energy requirements, safety, convenience of handling, operating limitations and disposal.

A corollary of this particular Panel activity is that a mechanism must be developed to bring hazardous items such as this to the Panel's attention in a timely manner.

EVA AND PREBREATHING

Extra-vehicular activity is a useful adjunct to the Shuttle's capability but, as currently planned, it is not without important limitations. To be most useful the suit should operate

at the environmental conditions sufficiently close to those of the cabin to eliminate the need for prebreathing in order to prevent the "bends." Current prebreathing time and protocol limits the emergency capability of EVA. The ASAP recognizes that the design of an all-purpose space suit, useful as a work station as well as an emergency device, is not simple but believes that the present design should be reviewed to make sure that it is acceptable.

It is not clear to the ASAP that there are major requirements for EVA except in some emergences or the replacement of failed elements of expensive satellites. The requirements for emergency use appear to the ASAP to preclude systems that require long hours at different pressures than the normal cabin pressure and extended prebreathing times. It is suggested that an analysis be made for different failure scenarios. Different EVA requirements will undoubtedly emerge and such requirememts could dictate EVA equipment design requirements.

MAIN ENGINES

With but one exception, all propulsion systems of the Shuttle functioned flawlessly during all the flights this year. The performance of each of the systems: the main engines (SSME's), the solid rocket boosters (SRB's) and the orbital maneuvering system (OMS) engines was within the range predicted. The one incident that marred this otherwise perfect record was the failure of the SRB recovery system in the STS-4 flight. This failure had no effect on the mission itself although the SRB motor cases were lost. The subtle cause of this failure was identified and the corrective action implemented for the STS-5 flight succeeded in overcoming the problem.

The certification program for the FPL (109%) version of the SSME, in contrast, has been beset by test failures and problems

that have impeded achievement of engine certification. There were two serious incidents, both resulting in significant loss of hardware. Both of these failures involved developmental hardware changes, in one instance installed on a certification engine. Failure reviews were conducted, the causes identified and corrective actions implemented. The loss of hardware suffered exacerbated an already existing problem of limited engine hardware availability. The Panel has noted in the past its concern about the meager supply of hardware in the SSME program.

The problems that were encountered with SSME turbomachinery during development and certification of the RPL (100%) version of the engine have reappeared in the FPL program. This is most probably a consequence of the higher speeds and operating temperatures associated with operating at the FPL thrust level. These problems include turbine blade cracking and sheet metal cracking in the HPFTP and bearing wear and distress and subsynchronous-whirl in the HPOTP. All of these phenomena are life-limiting. As a consequence, during the FPL certification program frequent replacements of the turbopumps have been required. As of the end of October 1982, no FPL high-pressure turbopump had been able to accumulate more than 2500 seconds of operation without removal for cause.

There exists a program of design changes to the turbopumps intended to alleviate the problems encountered. It is the consensus of the several groups that have examined the situation that, with continuing development and the present approach to certification, an engine with satisfactory and safe performance at 109% should be achieved albeit with limited life. This will require frequent change-outs and inspections of the turbomachinery operationally.

There is a growing body of opinion that the origin of the problems of the turbomachines is of a "systems" nature rather than a set of discrete component difficulties. Under such

conditions a set of "fixes" to components within the physical constraints of the current design would, at best, be of limited value.

It would seem prudent, therefore, to undertake a major redesign of the turbopumps as the long-range solution to the problems. At the same time, in recognition of the planned rapid increase in launch rate and the long time (3-5 years) required to design, develop and certify redesigned turbomachinery, provision should be made to acquire additional spare turbopumps of current FPL design to accomodate the frequency of removals that is to be anticipated.

During 1982 the Panel also emphasized the SSME operational planning and status of logistics planning so that the inevitable emphasis on turn-around time reduction and turn-around costs will not introduce additional hazards. It was apparent to the Panel that substantial planning had been done but that the budget support of such plans may be a major constraint towards the attainment of safe rapid turn-around. Specifically:

o The critical dependence on the performance of the high and low pressure turbo pumps for both oxygen and hydrogen, coupled with only modest improvements in the mean-time-to-failure of these elements, suggests that more spares are essential. This would contribute to safety and would preclude dependence on cannibalizing production elements for flight support.

o Not apparent in the planning is the development of a dedicated facility or function for maintenance and overhaul turn-round of main engines. This will be necessary before minimum safe turn-around time and cost is achieved.

o Proposals within NASA which include contractor operation of major elements of the Shuttle or the entire STS for purposes of reducing cost should be carefully evaluated for their effect

on safety. This is noted in the discussion of the SSME because it is felt that operation, testing, inspection, and monitoring of flight data is still, and will be for some time, critically dependent on experience rather than on developed methods and procedures. Shifting turn-around or maintenance responsibilities to a separate organization should be approached with extreme caution.

o The decision to purchase another Shuttle is not a substitute for a fully developed logistics, maintenance, and spares program, which is properly funded. This comment applies to the entire STS program.

Appendix IV contains a more detail report on the above summary comments with particular reference to the investigations done in logistics and spares planning.

IMPROVEMENTS FOR ROUTINE OPERATIONS

NASA ORGANIZATION ARRANGEMENTS

The challenge of achieving true operationl status for the space transportation system is, in many ways, as rigorous a test of NASA's management and technical capabilities as the development effort itself. Recognition of this fact at NASA's top management levels is essential if the management challenge is to be met successfully.

The problem arises, in part, by the Shuttle's progressive testing and performance enhancement which will continue well into the operational flight schedule. This means that the experience and expertise of the development centers and their associated contractors must be readily accessible during this shakedown period that will last for another 5 years or longer. At the same time, however, an effort to build a truly operational system within an organizational structure dominated by the development centers is likely to fail. This is the core of NASA's present management dilemma.

The development centers--particularly JSC and MSFC--are not attuned by experience or philosophy to the management discipline that is essential to a successful commercial operation. Their understandable mutual competition within NASA for assignments and budgets, and their associated reluctance to let go of areas of responsibility once assigned, are serious obstacles to building a well-integrated and disciplined operational entity. In other words, the decentralization and fragmentation of responsibility inherent in a center-based strategy will, in the end, confound all efforts to operate the system efficiently through steering committees and task groups. At the same time, NASA cannot risk cutting itself loose from the centers' experience and expertise.

The Panel also recognizes the severe budgetary constraints that are likely to impede realization of an optimum logistics strategy in support of a routine and reliable commercial operation. For example, it would be unrealistics to maintain the level of spares that would routinely be obtained by a commercial airline operation. Similarly, a dedicated overhaul facility in the vicinity of KSC may also be an unrealistic expenditure, much as it might improve turn-around time. Numerous and difficult trade-offs will be needed in this budgetary environment. This fact heightens the need for a clearly defined line of reponsibility and authority within NASA to make these decisions.

It is not the Panel's responsibility to prescribe a specific solution to this management dilemma surrounding the Shuttle's transition to an operational commercial system. However, the significant safety considerations that are directly linked to this transition suggest several approaches or principles that should be considered by NASA management.

o The organizational arrangement within NASA that is to be responsible for commercial operation of the Shuttle should be determined and announced, even though full implementation of this arrangement might not be feasible for the next several years.

o As a first step, the management core of this operational organization should be established as soon as possible and given authority to resolve major management and budget issues that will inevitably arise among the development centers as they support Shuttle testing and enhancement during the transition period. This core group would logically be situated at NASA Headquarters. This is another way of saying that someone at or near the top must clearly be in charge to control the natural competition among the centers.

o The relationship of the development centers to the operational organization should be one of subcontractors,

providing the development skills and expertise as requested on a reimbursable basis. Budget and Shuttle performance improvement program decisions would be the province of the operational organization.

o The role of the Shuttle Processing Contractor must be recognized as evoluntionary, given the Shuttle's continuing enhancement and a host of other uncertainties. The operational organization within NASA must retain ultimate responsibility for the Shuttle's commercial operation, as well as defining the specific roles and responsibilities of the SPC. A similar Headquarters control of the roles and responsibilities of the potential payload processing contractor should exist.

o NASA should give serious consideration in the long term to establishing the operational organization as a Government corporation, in order to achieve effective separation from the developmenmt centers which otherwise might function as de facto commercial operators of the STS. The benefits of establishing such an entity whose sole reason-for-being was the efficient and reliable operation of the Shuttle could be significant. At the same time, such a separation might enable the centers to pursue their historic R&D roles more effectively.

TRACKING AND DATA ACQUISITION

Today the Spaceflight Tracking and Data Network (STDN) consisting of fifteen ground stations provides less than 20% coverage of the Shuttle in orbit. The transmission of both voice and commands on the FM uplink from the ground to the Shuttle and the transmissin of voice and telemetry on the FM downlink are provided by an S-band communications system operating at the relatively low data rate of 32 KBPS uplink and 92 KBPS downlink. There are four flush mounted antennas on the Orbiter vehicle which provide a dual redundant communications path to the ground stations.

In the near future the STDN will be augmented by two operational Tracking and Data Relay Satellites in geosynchronous orbit and separated by approximately 135 degrees and will be able to extend this coverage of the orbiting Shuttle to 85 - 90% These satellites - also called WESTAR - together with a ground station at White Sands, New Mexico, constitute the Tracking and Data Relay Satellite Systems (TDRSS). The system will provide NASA with telecommunication services as needed. Current plans include orbiting a spare satellite between the two active satellites that can be moved into position to replace a failed satellite. The Shuttle Orbiter S-band system will then be able to communicate with the ground through the TDRSS system and will do so whenever it can.

In addition, a wide-band communications link from the Shuttle Orbiter to the ground via the TDRSS system is currently planned. This link will be used for on-orbit transmission of 2 MBPS to 50 MBPS of scientific data and, on a time-shared basis, will also accommodate television, analog scientific data, experiment or operational tape recorder dumps, etc. A deployable 36 inch steerable antenna shared with the Orbiter rendezvous radar susbsystem, operating in the Ku band and stowed in the payload bay will be used for this communications link. Unfortunately, this Ku band system is only single-string for budgetary considerations but on the surface at least does not appear to be a safety related item.

When the TDRSS is proven to be operational, all but three or four of the STDN ground stations will be phased out. The target date is mid-1984. Although the direct communication ground link will then be far less than the current 20% coverage, the DOD ground facilities at seven locations world-wide will always be available as a backup should the satellite relay system fail. (It should be noted that this will not be the first time that a manned spacecraft has utilized satellites for communication - it was successfully demonstrated during the ASTP joint mission with

the Russians in the mid-seventies.)

No plans are currently underway by NASA to assess specifically the safety aspects of the new communications system and the ASAP has not yet been briefed on the subject. However, the Panel will request such a briefing sometime during the calendar year 1983. Scheduled tests of the system are planned for March and again in August of 1983 and the Panel will certainly wish to review those test results.

SURVIVAL CONCEPTS

Over the last few years the ASAP has participated in many discussions of crew survivability, particularly during the launch and possible ditching of the Shuttle as the result of an abort. Although the circumstance of a ditching is remote, the conclusion of analysts suggests that an intact structure from which escape is possible on ditching is not probable. Thus, an ejection system operable at lower speeds is perhaps the only practical solution to the ditching problem. It should also be configured to serve for some launch aborts. The standard ejection seats have already been determined to be impractical for more than two crew members but there is a current technology in use involving a tractor rocket that lifts a person through a suitable opening. Concepts show that after ejection of four crew members, the succeeding flight crew members move into position at the cabin opening before firing their rockets. This solution is very complex, but the Panel recommends that NASA study its application to the Shuttle with two to six crewmen and determine the cost to install in a new Shuttle as well as the cost and feasibility of retrofitting current Orbiters.

The Panel feels that an even more likely problem is a ground incident occasioned by a blown tire or gear failure on landing. Immediate ejection could not only save a major number of the crew, but would open more escape routes. This should be analyzed

in detail because a landing incident is believed to be more likley than the ditching or a major launch malfunction.

ROLE OF CREW VS. GROUND

The real time control and management of space missions by Mission Control has served well but requires extensive and expensive communications if continuous control is, in effect, to be maintained. This was necessary during the test mission of the STS and desirable where Shuttle misions are unique and relevant experts can be gathered at Mission Control. In the case of the Shuttle as a transport system, substantial economies would result if a greater degree of reliance on the crew were to be achieved. The crews must be permitted and aided to develop a reliance on their own capabilities in emergencies that may occur. It is suggested that crews should be encouraged to work toward the routine execution of the entire mission, calling upon ground assistance only in unusual situations. The ultimate savings will only be realized if the entire operational support structure is streamlined as a result of flight experience and appropriate divisions of responsibility are achieved.

ASAP PRIORITY LIST OF SAFETY IMPROVEMENTS

Over the years a number of suggestions have been made by the ASAP not to emphasize major hazards in the current design of the Shuttle systems but to note those systems which do not appear to be sufficiently simple or to have adequate safety back up and must, therefore, demand "every flight" detail checks and inspections before safety can be assured. The ASAP feels that NASA has not done a comprehensive study of this type of systems improvement but has concentrated primarily on improvements to the payload performance. As in prior reports and letters to NASA, the ASAP suggests such a review of the consistency of redundancy in the Shuttle systems designs and the potential for changing entire systems concepts to simplify operations by permitting

quick turn-arounds without "every flight" attention to the potential safety performance of the subsystem.

Without such a study it is not possible to defend any particular priority listing but the ASAP, on the basis of its collective judgment continues to feel concern about the following systems:

- The APU system - particularly the APU installation in the solid propellant boosters.
- The rudder-speed-brake mechanical control system downstream of the drive motors.
- The landing gear system, particularly the wheels and tires (can the ground attitude of the Orbiter be modified?).
- Crew escape (for maximum number) at launch and prior to potential ditching or during and after a landing accident.
- EVA system to reduce time from decision to emergence.

POLICY ISSUES FOR OPERATIONS

Whatever NASA decides to do with respect to organizational structure to support routine operations of the Space Transportation System, it appears to the ASAP that Headquarters attention should be directed to the creation or clarification of broad NASA policy in several critical areas. These include: logistics and maintenance planning, certification, configuratin control, and component life determination. A brief discussion under each of these headings follows:

LOGISTICS AND MAINTENANCE PLANNING

A comprehensive overall integrated logistics plan for the entire Shuttle system is essential and overdue. This should include all major elements; e.g., Orbiter, ET, SRB, SSME, OMS & RCS, etc. Overhaul and repair facilities as well as spares stocking and warehousing issues should also be addressed. The plan should address the "near term" problems specifically and give an outline of the "longer term" requirements. Even if this plan is altered shortly after issue, the discipline entailed in its preparation will have served its purpose.

A maintenance plan for the entire system should be evolved along the lines of the FAA Maintenance Review Board philosophy. This can be either a part of the plan in the preceding paragraph or alternatively developed as a separate task. It will be required, however, to examine the adequacy of the present spares procurement quantities.

The Maintenance Engineering Analysis (MEA) or Failure Modes and Effects Analyses (FMEA) process for all components of the Orbiter is admirably thorough but may be exhaustive and, therefore, completed too late to be of value for the plans mentioned in the two previous paragraphs. While MEA's will be essential for major components, a more practical approach using

flight line and launch pad experience should be considered in the interests of placing spares orders immediately. A small task force could probably accomplish this if given a suitable mandate.

The spares quantities which have been ordered thus far and which were declared in General Abrahamson's logistics status review at KSC on November 9 to be essentially completely delivered in some cases, are probably insufficient. The small task force referred to in the previous paragraph could examine this question, but if the spares of SSME's and their major component are any criterion, then there may be a problem. Certainly in the interest of safety we cannot continue the present practice of "cannibalization" and robbing of the production line to meet each launch date.

The prospect of eliminating or reducing the coverage of certain maintenance manuals, illustrated parts catalogs and wiring diagram manuals in the interest of economy is viewed with dismay. The success of the current concept, especially in the longer term (say 1990), will be partly dependent upon adequate and accurate publication.

The "sustaining engineering" function should be critically examined to avoid duplication between NASA and the Shuttle prime contractors. If it is eventually vested in the SPC group, it should draw skills from each major contractor and take due notice of the problems of continuity of experience which might be endangered by attrition, retirements, and the like. Obsolescence of some of the equipment and disappearance of some smaller vendors will be a special problem in this respect in the"longer term."

In addressing the above, it may be useful to study "Notes on Relationships of Shuttle Program to Commercial Airline Logistics" November 20, 1982, included as appendix V of this report.

THE CERTIFICATION PROCESS

In the process of reviewing changes for performance improvement and the basis for certification, the ASAP is concerned that the certification process for such changes is inconsistent, i.e., the rigor of the originally specified certification process.

Examples of changes that may have had less rigor in their certification are: the safety factor reduction in the new light weight external tank and the decision not to test to ultimate load, the substitution of quilted material for the silicon thermal protection tile over large areas of the Orbiter. Taking such actions during an experimental program is inevitable, but steps should be taken to complete certification of all significant changes.

The suggestion by the ASAP is that NASA Headquarters institute a review of the total certification process for Shuttle hardware as well as support functions such as software certification, ground support processes, maintenance monitoring, etc. It is further suggested that the policy for certification and the approval for deviation be a Headquarters responsibility.

CONFIGURATION CONTROL

The objective of a certification program for a vehicle is to validate that all of its parts in fact perform together as a completely configured system. Substitutions of components or subsystems that have not been involved in such a formal integrated test program could invalidate the certification status of the vehicle by changing its configuration.

Several times during the year the Panel was presented with information regarding configuration identification program related to the initial builds underway for the remaining Orbiter vehicles. However, at some of the subsystem levels the detailed configurations have not always been determined. For example, while investigating the logistics support plans for the SSME, we found that complete indentured parts list does not yet exist for full-power engines. We believe there are many issues still open on the final full-power engine configuration. Lack of a detailed indentured parts list is cause for concern with regard to even defining explicitly the baseline for a configuration control program on the SSME.

Shortly before the STS-5 launch there was even some discussion as to whether all three engines would have the same certified configuration as a result of the impeller damage on the pump of one engine and lack of an available replacement with identical configuration. Although this problem was "resolved" by using the damaged pump, it highlights another issue; namely, how to maintain a certified system configuration without an adequate supply of configured components for replacement.

Because changes are being continually introduced to correct problems identified either during development or from flight operations, it is likely that each of the four Orbiter vehicles

will have different, as-integrated, configurations at the detailed level. This may be true also in the case of the external tank and the solid boosters; at least for the next several years. Furthermore, the extremely limited replacement hardware supply will cause changes to the as-integrated configurations through substitution of new design components or cannibalization of older design components. This is particularly probable on the engine, power supply and electronics subsystems.

It is the Panel's opinion that NASA must adhere to a rigidly disciplined methodology in which each vehicle's configuration is identified and recorded in detail, and its individual certification status maintained. There should be no planned substituion of components without a full understanding of the implications to the overall system operation and safety. The computerized configuration and validation records combined with change control rules should also form the basis for the logistic maintenance and reliability programs. One must particularly guard against changes made under the pressure of an imminent launch schedule where system implications cannot always be identified nor assessed.

An example that amplifies the above concern was raised by the premature separation of the parachute riser lines on the SRB cases during STS-4. In this case, a change in operational concept was coupled with a hardware change. However, it appears that a change in switch sensitivity may have occurred which resulted in the riser line release at the low g-level of the frustum separation event. The important safety implication is that an adequate vehicle Configuration Control Program involves not only the documentation of a fully certified system configuration and a disciplined change authorization procedure, but also quality control at the field level to assure that components changed are as specified.

COMPONENT LIFE DETERMINATION

In the design and development process for the Shuttle system, specifications were set up for each element and then a test program devised to demonstrate that the component would qualify for the desired life under the postulated conditions. Now that the Shuttle is flying, we have the opportunity to check whether or not the real conditions are as predicted and to determine the actual life of the component. This information is not only needed in the spares and logistics program, but will establish what the real margin of safety is for the various subsystem of the Shuttle. These data are vital for the guidance of the sustaining engineering program and must be obtained even though the necessary test and inspection may increase estimated costs and lengthen the turn-around time in the near term.

FLIGHT SAFETY FOR NASA AIRCRAFT OPERATIONS

During 1982 a series of accidents in aircraft operations made it clear that further emphasis on operational safety for support and test aircraft was necessary throughout the NASA organization. The ASAP, responding to a specific request from Administrator James Beggs, issued a letter report on September 13, 1982 (see Appendix VII).

Following the Panel report, NASA Headquarters initiated reviews of JSC and LaRC by ECO System International Company resulting in their report "NASA Flight Operations Review". In the ECO report, as well as the ASAP review, studies of the distribution of accidents as to cause such as weather, pilot error, powerplant, etc., have shown that pilot error is the principal culprit. This is true whether the class of operation is commercial airline, general aviation, or military. There is no reason to believe that NASA flight operations are any different.

Assuming that pilot error will be the principal cause of future NASA accidents, it is clear that the normal management approaches to discipline and procedures must be augmented and monitored.

Pilot errors can be attributed to training, current proficiency, physical condition, and mental attitudes such as carelessness or lack of patience. NASA has special problems because of the variety of its flight operations and the wide spectrum of pilot experience.

Supervision is a necessary, but not sufficient, condition to combat pilot errors. Selection, training, proficiency, and physical conditioning are some of the factors that can be monitored but when the wheels come up into the wells, the pilot is on his own and pilot attitude governs flight safety.

Pilot attitudes are a result experience, training, and by examples set by other pilots of established reputation. In this respect, NASA has a wealth of expertise that can make a major contribution. The ASAP suggests an education program that could be sponsored by the Intercenter Aircraft Operations Group (ICAOG) which could take the form of a series of "leadership" seminars to be given at weekly (or monthly) flight safety meetings held at various centers.

The "stable" of experienced and famous test pilots NASA employs is large. It is felt that a series of seminiars on interesting subjects by selected speakers would instill in the younger and less experienced pilots an appreciation of the disciplines and attitudes that make for safe flying and allowed these senior pilots to achieve a remarkably accident free career.

The program could include:

1. The flying characteristics of the B747 and the problems of trucking the Orbiter across the country.

2. LaRC discussing stall and spin avoidance and recovery techniques.

3. The pilots could give a talk on traffic control and communications around and approaching busy airports like JFK, LAX, O'Hare, Atlanta, and Washington National.

4. DFRC might decribe some of the special techniqes and precautions taken in establishing speed and altitude records.

5. Review experiences in flying large delta-wing aircraft, e.g., SR-71, B-1.

6. Some of the hazards exposed and lessons learned through the NASA Aviation Safety Reporting System could be discussed by an appropriate speaker from Ames Research Center.

NASA response to previous recommendations has been entirely positive although all programs based on these suggestions have not as yet been implemented. The extent to which the centers implement standard, cooperative programs and the progress on utilization of the Intercenter Aircraft Operations Group will be reviewed and monitored by the ASAP in 1983.

PLANS FOR ASAP 1983 EFFORTS

During 1983 the ASAP intends to concentrate on the progress of the space Shuttle flight experience with particular emphasis on the confirmation of the design flight envelope, maximum c.g. limits, maximum landing weight, and maximum reentry heat load. In addition, particular attention will be paid to those systems that should continue to have individual inspection, refurbishment, or flight-to-flight replacement to maintain safety in routine operations.

In addition, the ASAP intend to concentrate on the improvement of systems to enhance performance or reduce cost and to be certain that such changes do not add extra hazards. It is hoped that such changes will be made for the specific purpose of reducing hazards. It is the conviction of the ASAP that changes which reduce specific requirements for flight-to-flight maintenance or part replacement will not only reduce hazards but also cost of operation. 1983 should see the use of the heads-up cockpit display making possible the demonstration of autolanding.

Changes now planned that will require specific attention are the light weight external tank and the filament-wound solid rocket propellant cases. These designs will be followed as they mature. Not yet planned nor defined are changes to reduce the hazard to the crew in a number of potentially survivable incidents such as ditching, launch malfunctions, and hard landings. Elsewhere in this report the ASAP has suggested a serious study of progress if it is initiated.

As operations expand there will be a variety of payloads, many of which may have the potential of increasing the hazards for routine operation. Of particular concern are the payloads which have propulsion and pyrotechnic elements or extend beyond the payload bay door envelope. Of particular interest is the wide-tank Centaur.

A major change in Shuttle communications and geographical communication coverage will take place with the introduction of the TDRSS satellite based communications system. During 1983 the Panel will review the details of this system and the potential it has for hazards or the removal of present hazards to safe operations.

NASA AEROSPACE SAFETY ADVISORY PANEL

APPENDIX I

LISTING OF PANEL ACTIVITIES FOR CY 1982

Panel fact-finding sessions have been conducted on the average of three times per month for 1982. Members and consultants have during this same period visited six NASA centers and facilities (ARC, DFRC, LaRC, JSC, MSFC, KSC) as well as NASA Headquarters, and three NASA prime contractors. Although these have been focused on the Space Transportation System, there have been a number of fact-finding visits aimed at reviewing and assessing aeronutical operations and attendant flight safety. The Panel has, where practical, participated in a number of significant in-house reviews; e.g., Flight Readiness Reviews, STS Mission Control activities. Panel efforts have been supported by the Panel Staff Director through in-depth and continuous participation and reviewing of STS program/project activities and aeronautical R&D and administrative flight safety activities.

The breadth of Panel discussions goes from the NASA Administrator and Deputy Administrator to Program Directors on into the subsystem design and test personnel (the "hands-on" people). Beyond this is the Panel's annual report provided to the NASA Administrator and through testimony before the appropriate House and Senate subcommittees in January-March period. Where requested, the Panel provides individual support to special review teams such as the Solid Rocket Booster STS-4 Review Group and the Shuttle Main Engine (SSME) Assessment Group.

APPENDIX I

SUBJECT: Panel Fact-Finding Sessions, CY 1982

Date	Location	Attendees/Subject
1/21/82	Headquarters	Annual meeting, 1981 activities (Panel)
2/24/82	Wash., DC	Testimony before Congress (Panel)
2/25-26/82	JSC	Discuss results derived from STS-2 which affect future fight/mission hardware (Panel)
3/9-10/82	KSC	STS-3 Flight Readiness Review (Parmet, McDonald, Hawkins)
3/15/82	Headquarters	Flight test activities, aero safey meeting w/Beggs (Davis)
3/20/82	KSC	L-2 review for STS-3 (Hawkins)
3/21-22/82	JSC	STS-3 mission control room (Davis)
3/28-29/82	JSC	MCC operations, preparation for landing STS-3 (Davis)
4/26-28/82	Rocketydne	SSME status (Himmel)
5/5-7/82	HQ/MSFC	Met w/codes O & M STS development & operation. ET, SRB, SSME status (Panel)
5/10-11/82	LaRC	Aircraft flight safety (Davis)
5/18-19/82	MSFC	SSME FPL incident (Himmel)

5/26/82	Headquarters	Orbiter capability, assessment, expendable launch vehicle, etc. (Hawkins)
6/10/82	MSFC	Filament wound case for solid rocket motor (Hedrick)
6/11/82	RI/SD	STS structural adequacy (Hedrick)
6/14-16/82	KSC	STS-4 FRR; SPC discussions & briefing (Battin, Parmet, Grier were at SPC & FRR; Davis at FRR)
6/22-23/82	KSC	SSME task force (Himmel)
6/25/82	KSC	FRR (Grier)
6/26/82	KSC	STS-4, L-2 review (Grier)
6/30-7/4/82	JSC	Mission control room STS-4 (Davis)
7/7-9/82	DFRC/ARC	Aviation Safety (Davis)
7/19/82	Michoud Assembly Facility	Light weight external tank (Hedrick)
8/2-5/82	HQ/MSFC	Chief Engineer's review Panel re SRB failure on STS-4 (Himmel)
8/9-13/82	RI/Palmdale RI/Downey	Logistics, SSME, STS & Orbiter performance Palmdale operations (Panel)
8/9/82	DFRC	HUD, SIMS for STS

		missions (Davis)
8/19-20/82	Ames/DFRC	Discussion on similarities between Orbiter & SR 71 landing. Discussin w/test pilots at DFRC on landing characteristics (Davis)
8/26/82	ARC	Orbiter TPS (Hawkins)
9/13/82	Headquarters	EVA meeting (Hawkins)
9/14-15/82	RI/Downey	STS-5,-6 design certification review teleconference (Grier)
9/16-17/82	JSC	HUD, landing gear, crew egress (Davis, Rothi)
9/28/82	Rocketdyne	SSME logistics & status (Elverum & McDonald)
10/1/82	Headquarters	STS-4 anomolies & STS-5 configuration differences (Parmet)
10/25/82	KSC	STS-5 FRR (Grier, Elverum, Rothi)
10/25-27/82	KSC	SSME Management Overview Board Meeting (Himmel)
11/2/82	RI/Downey	Orbiter: Applicatin of Airline method-logistics and spares (McDonald)
11/3-4/82	C. Draper Lab.	Stability and control of the Orbiter on re-entry and touchdown (Davis)
11/8-11/82	KSC	Management council meeting; STS-5; L-2 review (Panel)
11/22-23/82	KSC	Orbiter structures capabilities (Hawkins,

		Hedrick, Cohen)
12/13-14/82	KSC	Technical Readiness Review for FRF (Roth, Himmel)

APPENDIX II

Membership List of the AEROSPACE SAFETY ADVISORY PANEL

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APPENDIX III

BACKGROUND MATERIAL FOR LIGHT WEIGHT EXTERNAL TANK ASSESSMENT

Discussion

The shell structure should be able to maintain its structural integrity, i.e., not collapse or rupture, at values of loads up to some safe value (called ultimate load) above the maximum expected operational load (called limit load). The ratio ultimate load/limit load is called factor of safety (F.S.). A factor of safety is used to provide protection against uncertainties in load, material properties, manufacturing variations, etc.

The F.S. in general use for aircraft is 1.5. An F.S. of 1.4 was adopted for general use in design and certification of the STS, and the HWT was designed for an F.S. of 1.4. For the LWT the F.S. was reduced to 1.25 for loads categorized as "steady-state" or "well defined." The original F.S. of 1.4 was retained for loads categorized as "dynamic" or "all other". The composite F.S. equals 1.265 in the critical design condition for LH_2 tank shell buckling.

HWT Static Strength Test - The HWT was static tested in the MSFC vertical test stand in 1979. The critical test areas were submerged in liquid hydrogen so that material strength properties would be the same as in actual operating conditions. The LH_2 section of the HWT was pressurized to 32 psi, which is the lower limit of flight pressurization (the lower limit is critical for shell buckling). The maximum level of Orbiter thrust load applied is uncertain since it is reported as 113.5 percent of limit in one part of the test report and 130 percent in another part of the same report (MMC-ET-TM03-0, Volume III, "External

Tank LH_2 Strength Test Report). The HWT test specimen did not show any signs of distress at the load levels imposed.

LWT Static Test for Buckling - A limit load verification test was run on LWT-2 in the horizontal proof test stand at Martin Marietta's Michoud, Louisiana, plant. Gaseous nitrogen at room temperature was used in the LH_2 section to provide an internal pressure 23 psi greater than ambient. The 23 psi differential pressure was held constant while external loads were applied to produce the "equivalent"1/ of 100 percent design limit axial load in integral skin/stringer shell at the area2/ that was predicted by analysis to be most critical for panel buckling.

1/"Equivalent" is used here to indicate that the design limit load was reduced to account for the reduced modulus of elasticity of the 2219-T87 aluminum material at room temperature compared to the operating temperature of -423oF, i.e., loads are divided by the factor $(12.4 \times 10^6)/10.8 \times 10^6) = 1.1$

2/"The STAGS-C analysis by Martin Marietta indicated that the minimum margins for compressive buckling occurred at the 10:30 and 1:30 o'clock positions at Station 1702.

This test was carefully run so as not to exceed the local design limit stress. Because the internal pressure, which is stabilizing, was only 23 psi rather than the minimum operational value of 32 psi, it is estimated that the test demonstrated approximately 109% of limit load or 119% (i.e., 1.09 x 109) at rated power level of the main engines. It provides no margin to cover any variation in load or variation in strength. It is

unlikely that all LWT's will have strengths greater than LWT-2.

LWT Proof (or Acceptance) Test - In addition to the static test for buckling just described, which was performed on LWT-2 only, each production LWT receives a burst proof test as an acceptance test. These acceptance tests are run in the horizontal test stand facility at the Martin Marietta plant at Michoud, Louisiana. The acceptance test is designed to impose the "equivalent"1/ of 105 percent of limit load tension on all welds. The internal pressure alone is sufficient to proof load the axial welds. but five different combinations external loads are used in addition to the internal pressure to attain the proper loads on the circumferential welds. This proof test contributes nothing toward the verification of required compressive buckling strength of the LH_2 tank shell.

1/"Equivalent" is used here to indicate that the proof pressure was reduced to account for the reduced toughness of the 2219-T87 aluminum material at room temperature compared to the operating temperature of -423oF, i.e., pressures are divided by the factor 1.1. Since the high side of the flight ullage pressure regulation band is 34 psia and the LH_2 under flight acceleration is 6.4 psi then the proof pressure

$$P(proof) = (40.4 \times 1.05)/1.1 = 38.6 \text{ psig}$$

APPENDIX III

STABIITY OF SPACE SHUTTLE EXTERNAL LIGHT WEIGHT TANK (LWT)

David Bushnell and Bo Almroth

December 14, 1982

LMSC-D877306

LOCKHEED PALO ALTO RESEARCH LABORATORY
APPLIED MECHANICS: DEPT. 52-33, BLDG. 255
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STABILITY OF SPACE SHUTTLE EXTERNAL LIGHT WEIGHT TANK (LWT)

David Bushnell and Bo Almroth

ABSTRACT

The next and future launches of the Space Shuttle will include a redesign external (disposable) tank. This tank is of lighter weight than that used to date. It has been tested to design limit load, not to ultimate load. During a certain phase of the launch there are regions of the tank subjected to destabilizing loads generated by the thrust of the Orbiter engines. Recently, the Aerospace Safety Advisory Panel, a committee that advises NASA Headquartes on issues involving the Space Shuttle, expressed concern about the adequacy of the new design with regard to buckling. The committee recommended that experts in the field of shell buckling be called in to evaluate the new design, render an opinion of safety, and make recommendations about possible further analyses and tests. David Bushnell and Bo Almroth were selected by the Panel and by NASA Headquarters to perform these tasks. On December 9th and 10th Bushnell and Almroth visited the Martin Marietta Company, Michoud Division, New Orleans, in order to evaluate the light weight tank design with regard to buckling. On December 11th they, representatives from Martin Marietta, the Aerospace Safety Advisory Panel, and NASA officials met at NASA Headquarters to discuss the buckling issue. As a result of Bushnell's and Almroth's evaluations, it was decided that the light weight tank could be flown on the next Shuttle launch without further analysis, but that nonlinear analyses with the use of the STAGSC-1 computer program should be performed with an eye toward future launches, during which the destabilizing loads are expected to be somewhat higher than those on the next flight.

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BACKGROUND AND PROBLEM DEFINITIONS

On Wednesday, November 24, 1982, Willis Hawkins, in his capacity as chairman of the Aerospace Safety Advisory Panel for NASA's Space Shuttle program, telephoned David Bushnell about a buckling issue in the Space Shuttle external tank. Hawkins asked Bushnell to call Grant Hedrick for details. That afternoon, Bushnell, Almroth, and Hedrick held a telephone conference in which Hedrick defined the issue.

Figure 1 shows the Space Shuttle external tank (ET). At a certain phase of operation following launch, local regions of axial compression develop just forward of longerons by means of which Orbiter thrust loads are transferred to the external tank. In this region the external tank, which contains liquid hydrogen and is internally pressurized to 32 psi, must be designed so that it will not buckle under the combined hoop tension and axial compression. The tank is stiffened internally by stringers with T-shaped cross sections, as shown in Figure 3. (First two rings in the foreground are typical.)

On Space Shuttle flights to date the disposable external tank has and an inert weight of 7100 pounds. This tank, henceforth called "heavy weight tank" (HWT) or "standard weight tank" (SWT), was tested under cryogenic conditions to an ultimate load of 1.40 times design limit load. Because of the need to reduce weight, a new lighter weight disposable tank has been designed, henceforth called "light weight tank" (LWT), with an inert weight of 60500 pounds. About half of the weight saving came from structure; the skin between stringers was reduced in thickness in certain areas, the cross sections of certain rings were reduced, and material was taken out of the aft portion of the large longerons by means of which orbital thrust loads are transferred to the LH_2 tank.

The new light weight tank has been tested to design limit

load in the horizontal proof test stand at Martin Marietta's Michoud, Louisiana, plant. A new definition of ultimate load, 1.25 times design limit load, has been accepted. Buckling analyses conducted at Martin Michoud by Dale Karr indicate that the new tank will withstand the new ultimate load. The new tank will fly on the next launch, how planned for January, and on future Shuttle flights.

Due to the pressures of time and money there is currently no plan to test the new tank to the new ultimate load. This lack of a test on a stability-critical structure designed to a lower margin over design limit and than the previous tested tank worried Hedrick. Accordingly, as a member of the Aerospace Safety Advisory Panel, he advised that an independent evaluation of the analysis methods and the new design with regard to buckling be carried out. Bushnell and Almroth were consulted as experts in this field.

After the telephone conference with Hedrick, Bushnell called Hawkins on November 24 to request that Hawkins officially introduce Bushnell and Almroth to whoever at Martin Michoud has overall responsibility for the structural integrity of the Shuttle external tank. Bushnell and Almroth would then gather enough data from Martin in order to render an opinion.

On Friday, December 3 Gil Roth at NASA Headquarters contacted Bushnell at Lockheed. Roth requested that Bushnell contact Al Norton at Martin Michoud to set up a visit by Bushnell and Almroth on Decemer 9th and 10th at Martin in order to learn details of the geometry and buckling analysis conducted at Martin. Bushnell first called Norton, who directed him to Dick Foll. Foll knew about the proposed visit to Martin by Almroth and Bushnell; he was agreeable to the proposed dates of the visit; and he supplied the name, Jon Dutton, manager of the department reponsible for the analysis of the Shuttle external tank. Bushnell called Dutton in order to obtain certain details

of geometry and loading that would permit some analysis to be conducted at Lockheed with PANDA, BOSOR4, and possibly STAGSC-1 before the visit on December 9th and 10th. These details were supplied to Bushnell on Friday afternoon, December 3 by Dale Karr.

Following the telephone contacts at Martin Michoud, Bushnell called Roth at NASA Headquarters to confirm the dates of Almroth and Bushnell's visit to Martin. Roth told Bushnell that there would be a meeting at NASA Headquarters on Saturday, December 11, in General Abrahamson's office to discuss the buckling issue and to learn the opinions of Almroth and Bushnell. This meeting would be attended by General Abrahamson, Gil Roth, Willis Hawkins, Grant Hedrick, Al Norton, Dick Foll, Jon Dutton, Bo Almroth, David Bushnell, people from NASA Marshall Space Flight Center (MSFC), and others.

On Friday, December 3 and Monday and Tuesday, December 6 and 7, Bushnell conducted buckling analyses of the local regions of the Shuttle external tank subjected to compressive stresses. PANDA and BOSOR4 runs were made. Results from these two programs agree with each other for cases in which both apply. A preliminary conclusion, from the data supplied by Dale Karr over the telephone and from PANDA and BOSOR4 calculations based on these data, is that the new, lighter weight Shuttle external tank has sufficient margin with regard to buckling.

ET CONFIGURATION

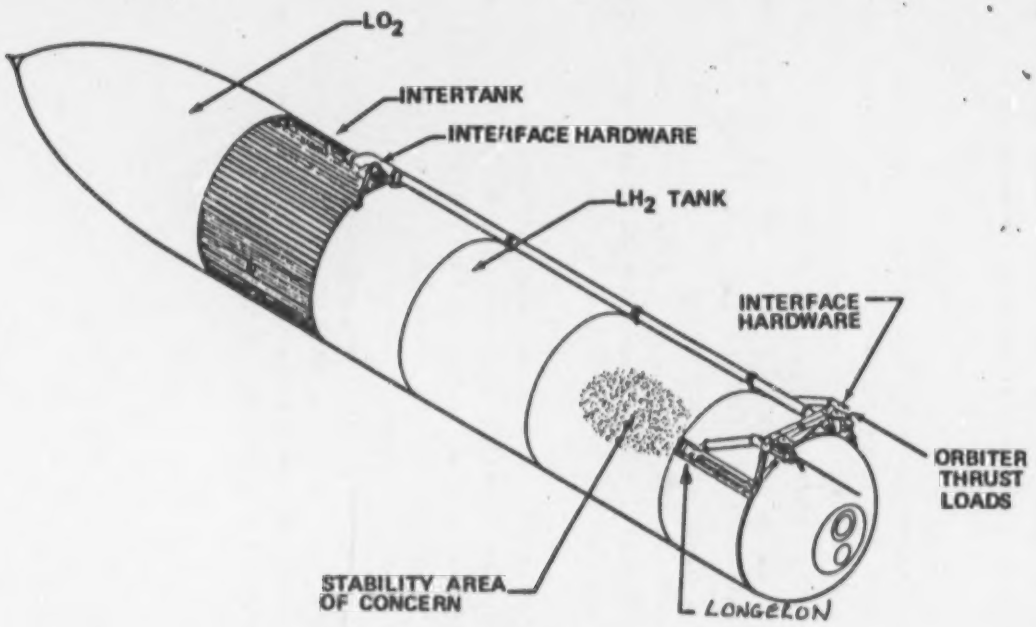


Fig. 1 External tank configuration showing area where buckling is possible

APPENDIX IV
MAIN ENGINE

September 29, 1982

TO: Willis M. Hawkins
FROM: Jerry Elverum and John McDonald
SUBJECT: NASA-ASAP Visit to Rocketdyne to Examine SSME Logistics and Support, September 28th

As noted in Gil Roth's memo of August 18th (page 2) we visited Rocketdyne, Canoga Park, to review the logistics and support aspects pertinent to the SSME. A detailed presentation was given to us and two copies (BC 82-223) have been sent by Rocketdyne directly to Gil Roth. The program was divided into two main parts:

(a) turn-around operations and maintenance together with support systems, and

(b) an outline of the precepts upon which the support activities are being based.

Vince Wheelock (SSME Logistics Manager) presented part "a" and his Chief of Schedule Management, Harvey Colbo, gave part "b". A copy of the Rocketdyne organization chart is attached hereto (attachment 1). Persons also attending are listed in attachment 2.

These notes will include a discursive commentary upon the material presented to us, together with selected charts, and will conclude with some more specific recommendations of a form suitable for adaptation to the ASAP annual report.

MATERIAL PRESENTED AND DISCUSSION

Opening comments were that flight data were being continuously analyzed for maintenance action but it was conceded that there were just not enough data available yet from the four flight to refine the assumptions made - really prior to STS-1. It was stated that thee studies really commenced in the definition phase beginning in 1972 and used extensive Saturn experince background.

External visual inspections on the SSME were described followed by the turbopump breakway torque and axial shaft travel pre-flight checks. Internal inspections of the entire powerhead assembly and the main combustion chamber were outlined - these consisting principally of borescope ports using both fibre-optic and rigid borescopes. Camera (35 mm) shots can be taken in some cases - mostly with rigid borescope applications. Drying purge of the combustion chamber and various leak checks were described including checks with throat plugs installed.

Electrical checks look fairly straightforward, probably the least familiar to mechanics being controller memory read-out. All the preceding checks are accomplished with the Orbiter in the horizontal position but some, such as high-pressure fuel turbopump removal are time consuming tasks as the unit has to be disconnected from its ducts etc., and slid out on "Thompson rails" (a piece of GSE) every second flight.

The Rocketdyne team at KSC to accomplish all this seems to number about 35 men, about half of whom are involved on each shift in the pre-launch activities. Some 13 technicians, 4 inspectors and 2 or 3 engineers are normally required but like all critical borescope viewing techniques the "Mark I eye-ball" confidence will probably be placed in just one or two men who possess great experience. This connotes a critical training problem as launch rates increase.

Readiness maintenance tests with the whole Shuttle assembly on the launch pad were described and a few unscheduled maintenance items have been identified. Environmental protection sets (covers) for the SSME and for the RCS and OMS engine were described, but their installation after landing is rather difficult and time consuming because of the height from the ground. More specifically, only three sets exist at present - one at KSC and the other being available to be ferried to White Sands, Hickam, Kadena, Rota or Dakar as the abort case might be. The SSME's would have to be removed to provide ferry range-weight capability out of Dakar, Hickam and Kadena.

When the craft is on the launch pad at KSC the availability of only one set of SSME GSE means that each engine at the present time has to be worked on in series. It apparently takes six shifts or approximately 48 elapsed hours to remove the old engine and install the new. The usual supporting logistics analyses including resources such as facilities, maintenance crews, training, spares, handbooks and manuals etc. appear to have been well thought out and are based upon a DOD philosophy - e.g., organizational, intermediate and depot levels and a maintenance plan has been established to suit. Training manuals have been prepared and courses planned.

MTBR studies have been made of all principle components and assemblies and engine overhauls have been scheduled based largely upon these values. Support of this wide base of materiel was said to be "in the short term" based upon existing vendors' facilities and production units whereas, "in the long term" it would revolve around "dedicated facilities and systems." The terms were not defined in years and we drew the conclusion, erroneous perhaps, that they were feeling their way both in terms of experience with the flight hardware and available funding downstream.

The all-components total MTBR plots for the period 1976 through 1980 based upon test stand data and earlier similar engine data are shown in attached Chart C-9 and Rocketdyne expressed confidence in the conservatism of these based upon their approach of factoring the MTBR value. Chart C-9 shows this overall engine life growth plotted upon a linear scale. C-10 shows the major components of the engine and the asymptotic sections beyond FY '84 are intended to indicate that they don't expect to gain a great deal of data above the fully certificated (and realized) life level. It is of significance that the most crucial components, namely the HPFTP and the HPOTP are at the bottom of the totem pole, while the LPFTP and the LPOTP are not really very much better. Much of this is due to the actual experience over the four flights and the higher FPL involved. Chart C-34 shows the estimated data replotted from October 1980 to Octoer 1981 resulting, in effect, in a zero gain in MTBR throughtout that period. In fact, the plot shows a somewhat retrograde trend but the dotted line reflects optimism which, in our opinion, may not be fuly justified. Even if the life growth rates shown in C-35 are realized the effect upon available SSME spares levels could well be serious and some launches could suffer delay. The following plots (Charts C-36 through C-41) indicate the same optimism and C-38 and C-39 for the HPFTP and the HPOTP respectively should be examined carefully. There appears to be little justification for the revised "projected improvement" dotted line.

Taking the foregoing a little further and examining Chart C-52 it will be seen that the overhaul projections are rather awkwardly "bunched" especially circa 1993-1994. Rocketdyne believe that the natural occurrences of failures and other aberrations will tend to minimize some of the "bunching" and this may well prove to be true, but it is an uncomfortable precept with which to start the program. The last Chart, C-53, summarizes the expressed confidence level in terms of the halved MTBR assumptions. The principal conclusion we drew upon the basis of

the data presented is that additional spare SSME's or at least a larger spares float of high and low pressure oxygen and fuel turbopumps would provide some better insurance.

RECOMMENDATIONS (for the Shuttle program)

1. The MTBR analyses, while appearing to be very thorough in classical reliability study terms and rendered conservative by the "two times factor," do not appear to be in consort with the spectrum of early removals being experienced in the program to date. A comprehensive "best case - worst case" analysis should be considered covering the full range of reasonably possible contingencies, especially in the logistics and supply fields.

2. Results to date with a wide variety of "random failure" induced problems on the SSME indicate that the four pumps are likely to have MTBR's well below original expectations - at least for the next year or two. The high pressue fuel turbopump and the high pressure oxygen turbopump appear to be especially critical because of the limited spares available and the long lead times involved in procurement. Additional spare units would appear very desirable.

3. Planned grouping of the SSME overhauls should be re-examined to see if they could be more uniformly distributed over the period 1984 through 1994. While it is most likely that unforeseen incidents will affect the planned dispersion and tend to improve it, the present layout would appear to be prone to loss of overhaul technical skills in the workload "valley" periods and thus will run counter to safety and reliability requirements.

4. "Near term" support based purely upon "robbing" production hardware and placing reliance upon the vendors for overhaul and other technial service should be critically analyzed. The "near term" and "long term" time spans should be defined and very conscious steps taken toward the establishment of a properly based "dedicated overhaul facility," not the least

important of which will be the average age and experience level of the technicians employed. Employment stability and continuity is also an important factor in this respect.

5. From the overall safety and reliability viewpoints every possible effort should be made in planning to avoid dependence upon "cannibalizing," or robbing from production lines to meet flight date requirements. Such continuing support pressures inevitably run counter to safety because of the desire to adjust "red line," extend the life for just one more mission, and so on, to preserve intact the very expensive and highly publicly visible launch date schedules.

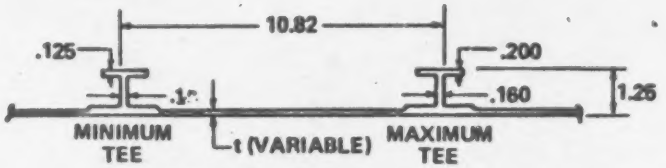
RECOMMENDATIONS (for the NASA-ASAP group)

It became clear in the course of the excellent Rocketdyne SSME presentation that the engine and related systems are much too highly specialized - and spread over too narrow a base in terms of the four Orbiter vehicles - to permit any other group than Rocketdyne to accomplish the overhaul and support tasks - or even for that matter, the critical pre-flight inspections. Further, it became more apparent at each logistics and support presentaton that if we, as a Panel, are to really understand the enormity of this task and to make valid suggestions, we have to spend much more time on visits and studies. Certainly the somewhat intangible, but never-the-less real, effects of logistics and support philosophies upon overall system safety warrant further attention.

cc: Parmet
Grier
Himmel
Battin

Attachment 1. Rocketdyne Organization Chart
2. Attendance list
3. Selected presentation charts

Enclosures



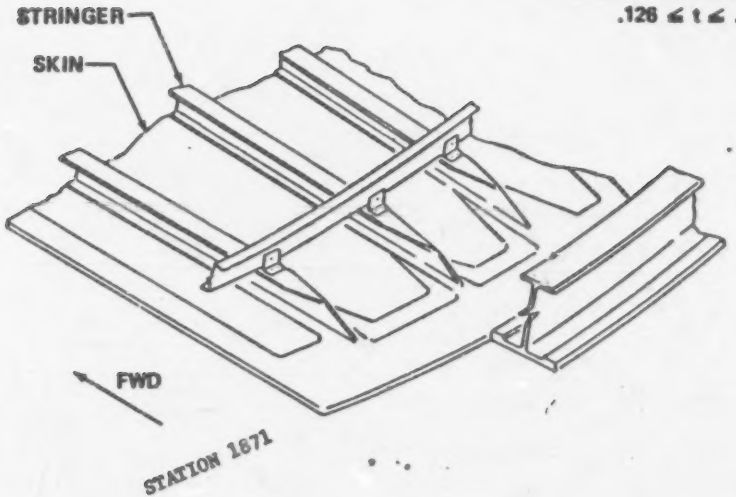


Fig. 2 Panel configuration in buckling-critical region

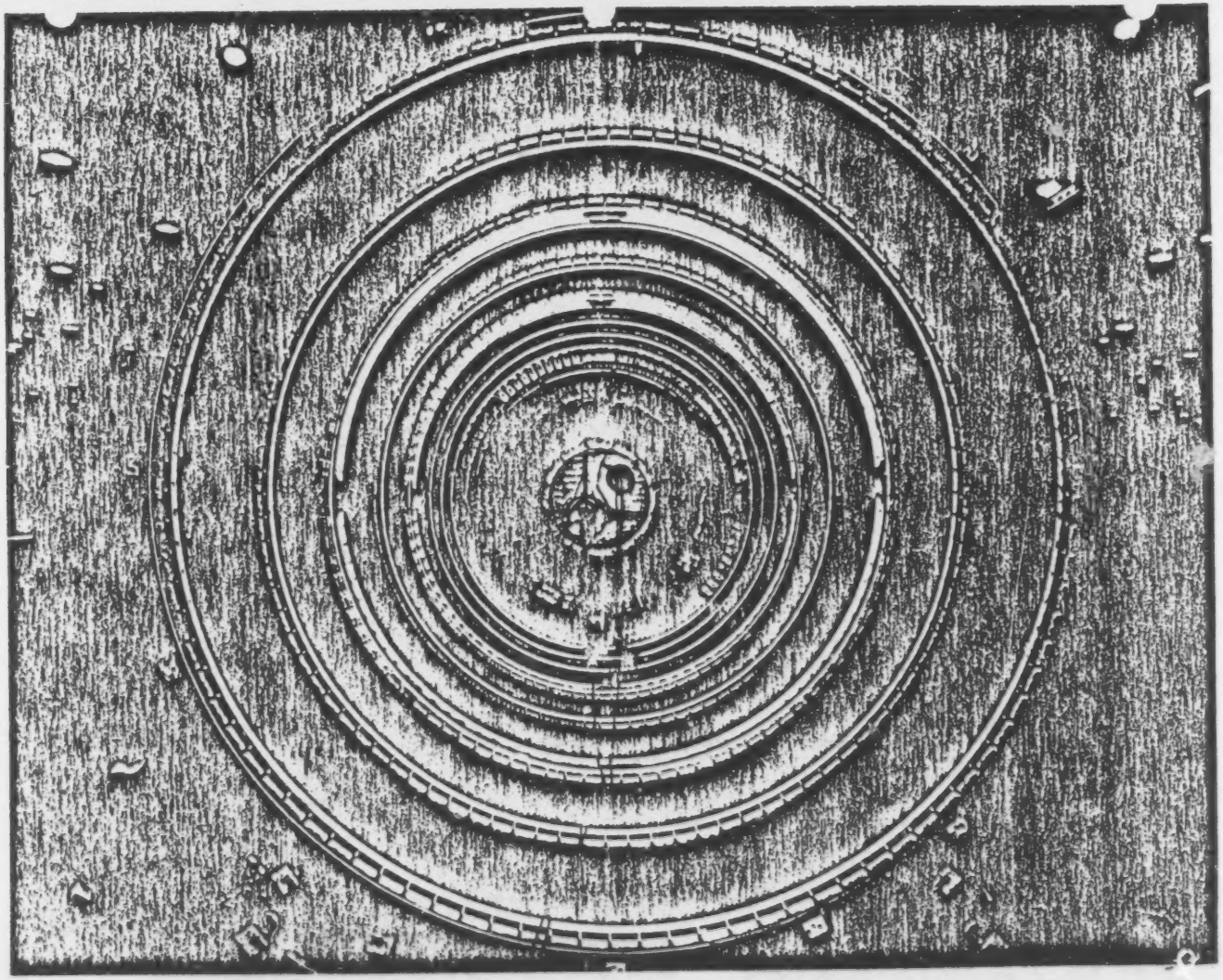
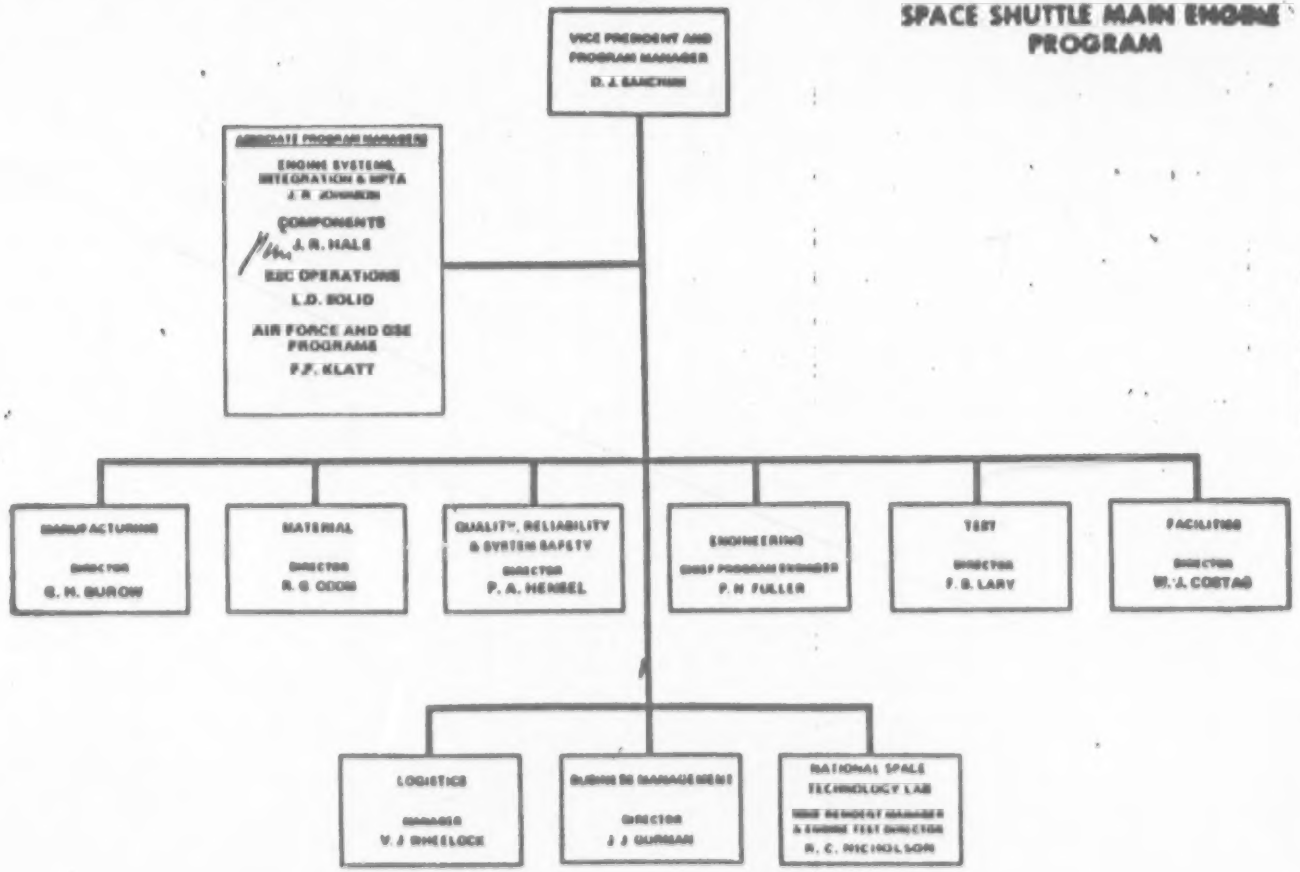


Fig. 3 Liquid Hydrogen Tank Interior (SWT) (Courtesy Martin-Marietta Corp.)

SPACE SHUTTLE MAIN ENGINE PROGRAM



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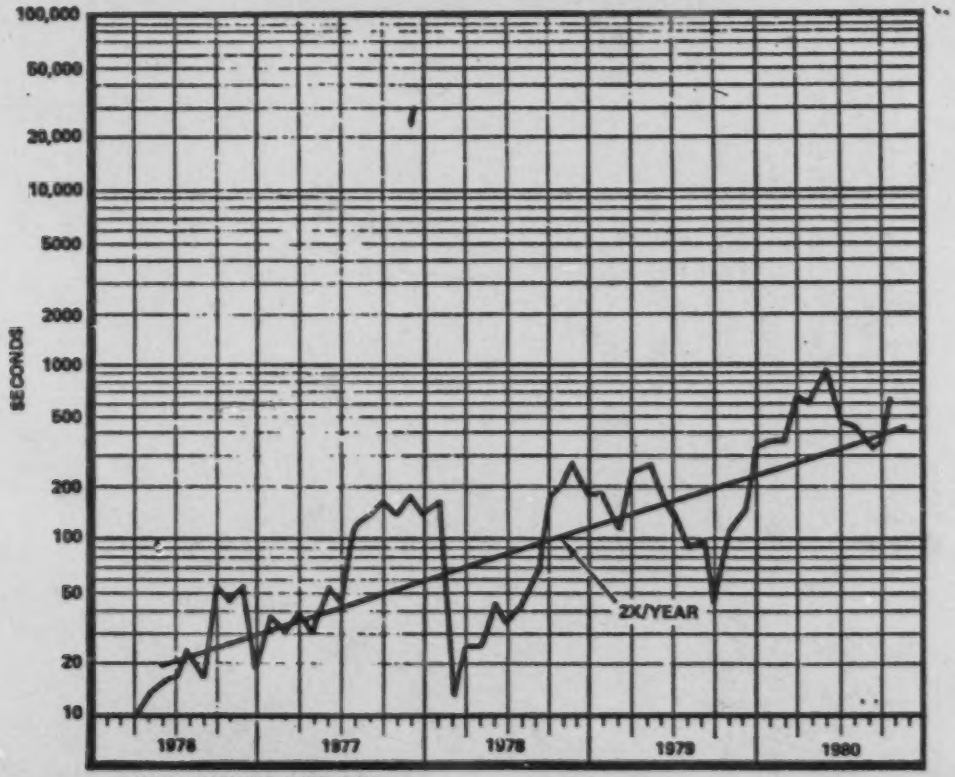
ATTACHMENT 1.

Attachment 2

Name	Organization	Position	Phone No.
Vince Wheelock	Rocketdyne	SSME Log Manager	X 2254
John F. McDonald	NASA (ASAP)		843-8311
Jerry Elverum	NASA (ASAP)		535-2374
Jack Weil	NASA/RKD	Project Mgt. Office	710-2261
Bill Mitchell	MSFC/SA-52	Logistic Management SSME Project Office FTS	872-0088
Norm Dingilian	Rocketdyne	Supply Support Mgr.	x 3095
Harvey Colbo	Rocketdyne	Schedule Management	x 3335
Frank Klatt	Rocketdyne	Assoc. Program Mgr. AF, GSE, SSME	710-3078

SSME MEAN TIME BETWEEN COMPONENT REMOVALS
ALL COMPONENTS TOTAL



• 3 MONTH MOVING AVERAGE

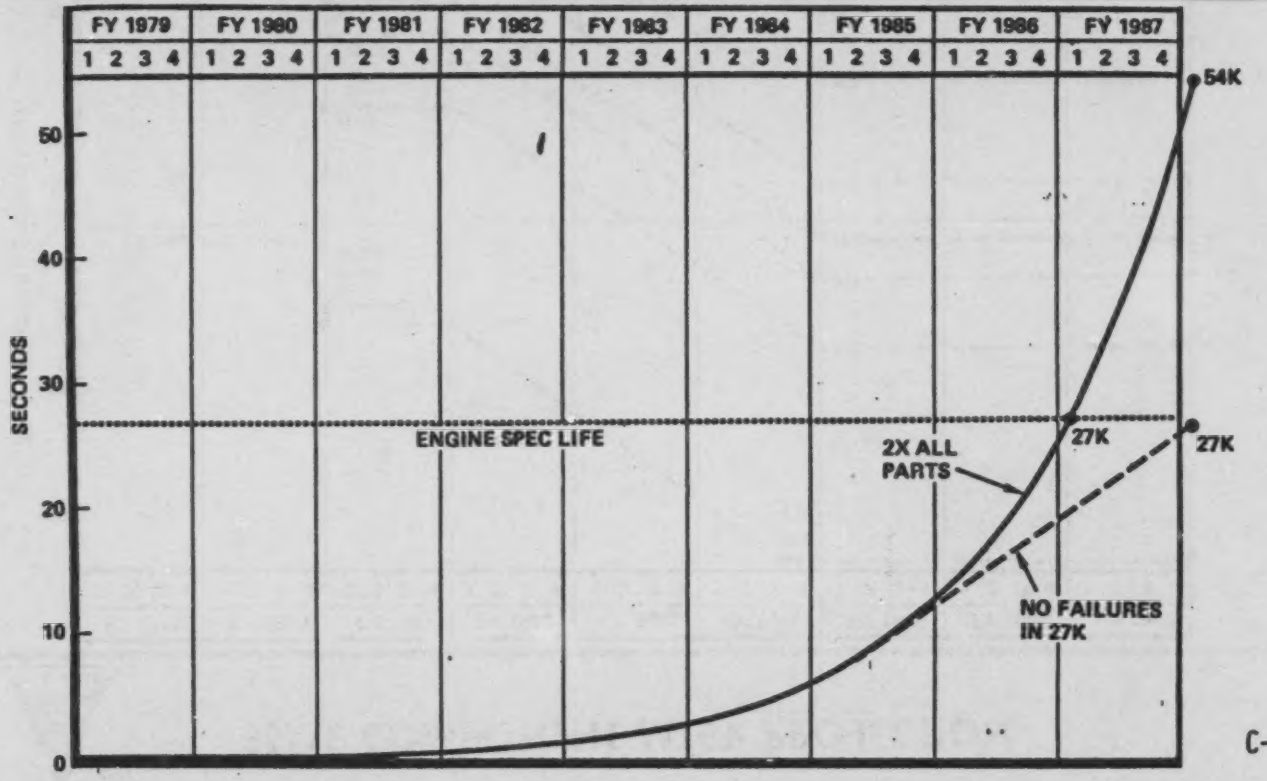
A ATTACHMENT 3

1590

C-8

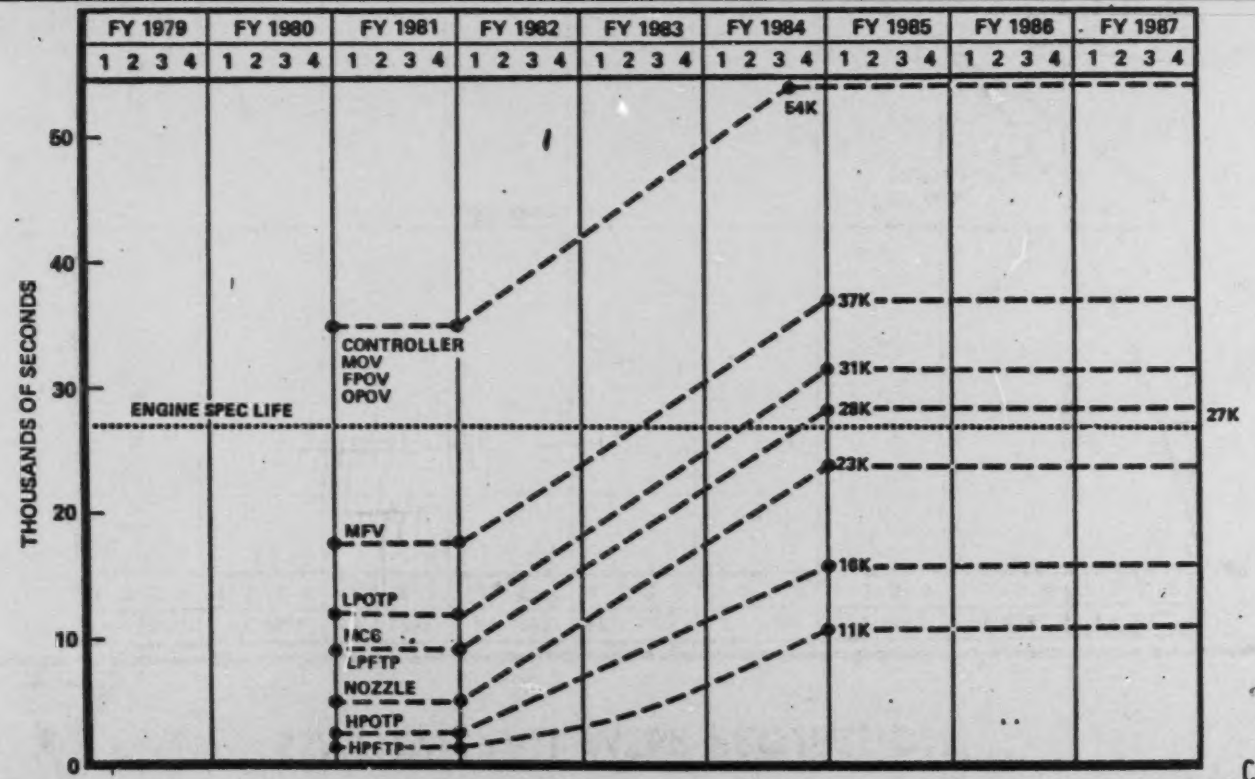
SSME OVERALL MTBR PROJECTION

3-15-82



SSME COMPONENT MTBR PROJECTION

3-15-82



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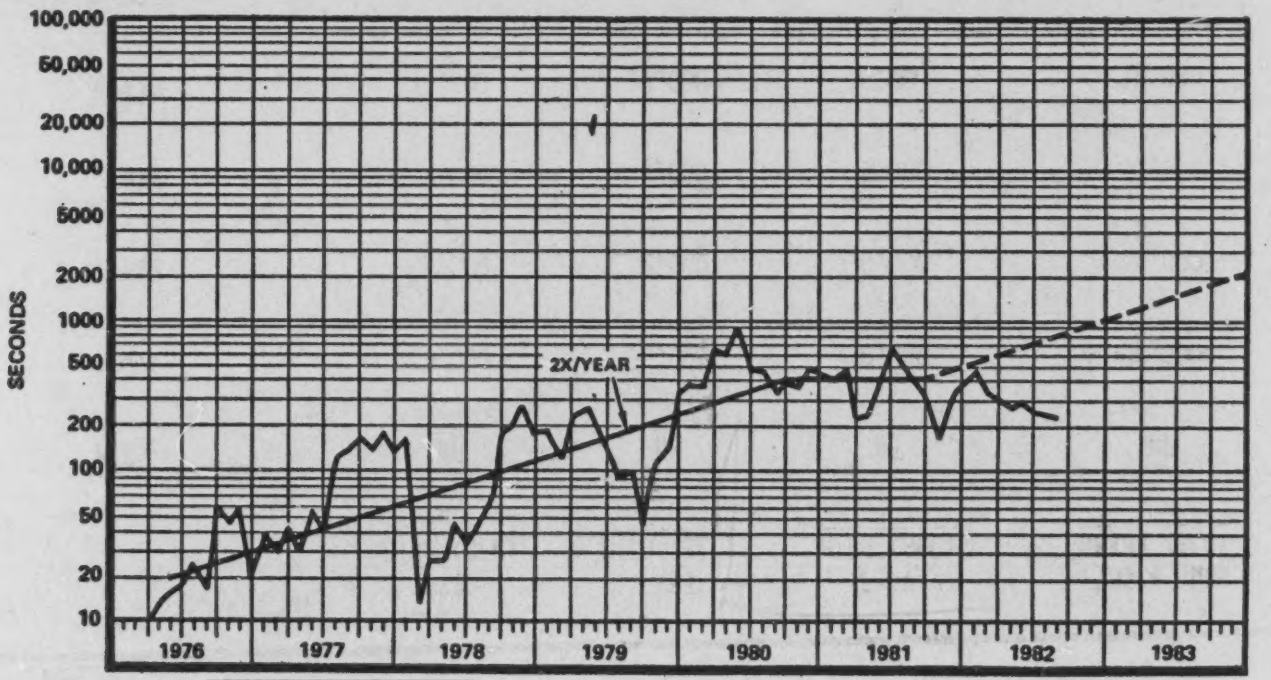
SSME MEAN TIME BETWEEN COMPONENT REMOVALS

23 SEPT 82



• 3 MONTH MOVING AVERAGE

1593

MTBR PROJECTIONS FOR SPARE PARTS PLANNING

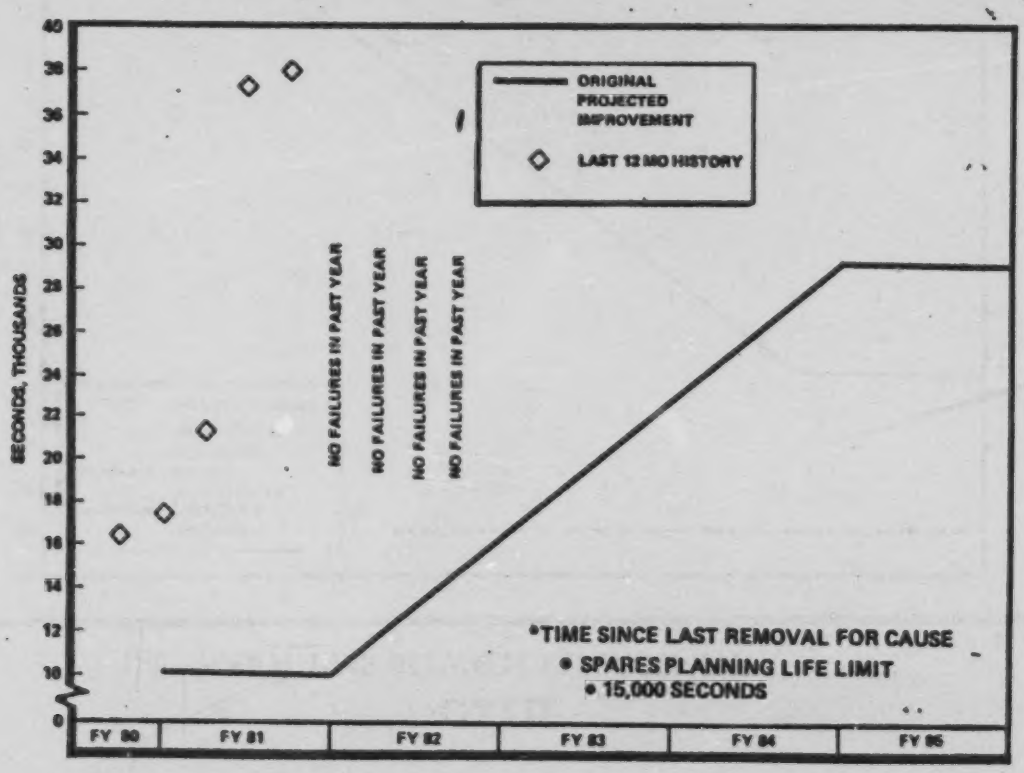
	FY82 MTBR (SEC)	FY83 MTBR (SEC)	FY84 MTBR (SEC)	FY85 & SUBS MTBR (SEC)
MCC	NF	NF	NF	NF
NOZZLE	30,000	30,000	30,000	30,000
HPFTP	1,500	2,000	4,000	6,000
HPOTP	2,500	3,000	5,000	7,000
LPFTP	16,000	16,000	16,000	16,000
LPOTP	8,000	10,000	15,000	20,000

NF = NO FAILURES

MCC

MEAN TIME BETWEEN REPLACEMENT

23 SEPT 82



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NOZZLE
MEAN TIME BETWEEN REPLACEMENT

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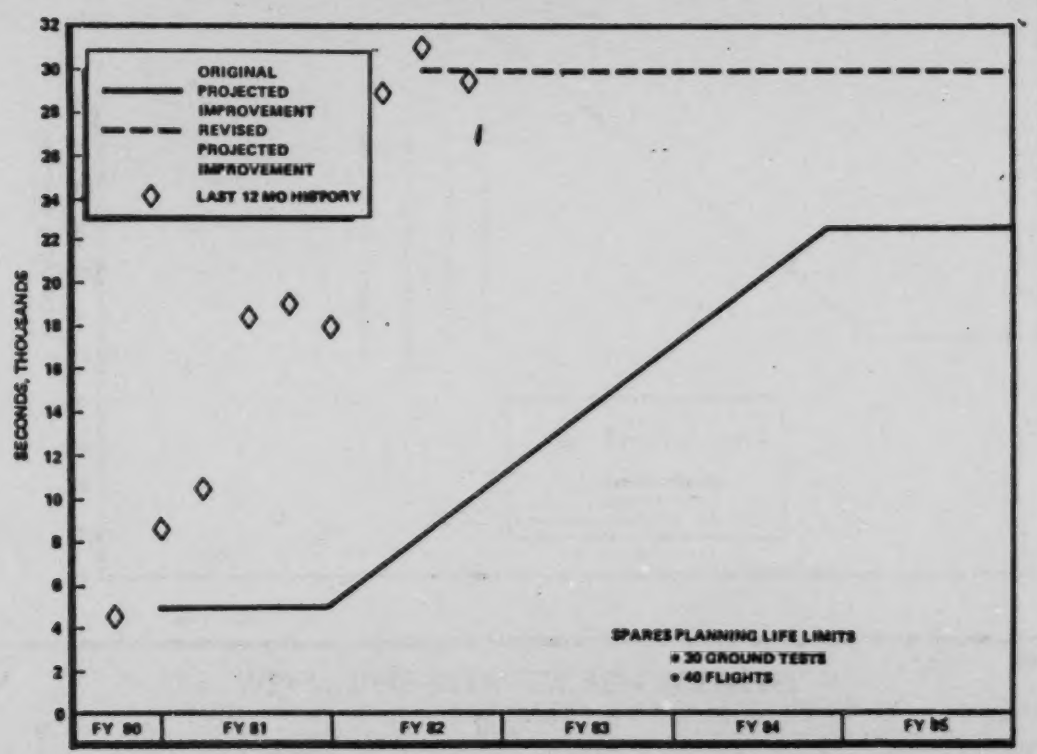

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HPFTP
MEAN TIME BETWEEN REPLACEMENT

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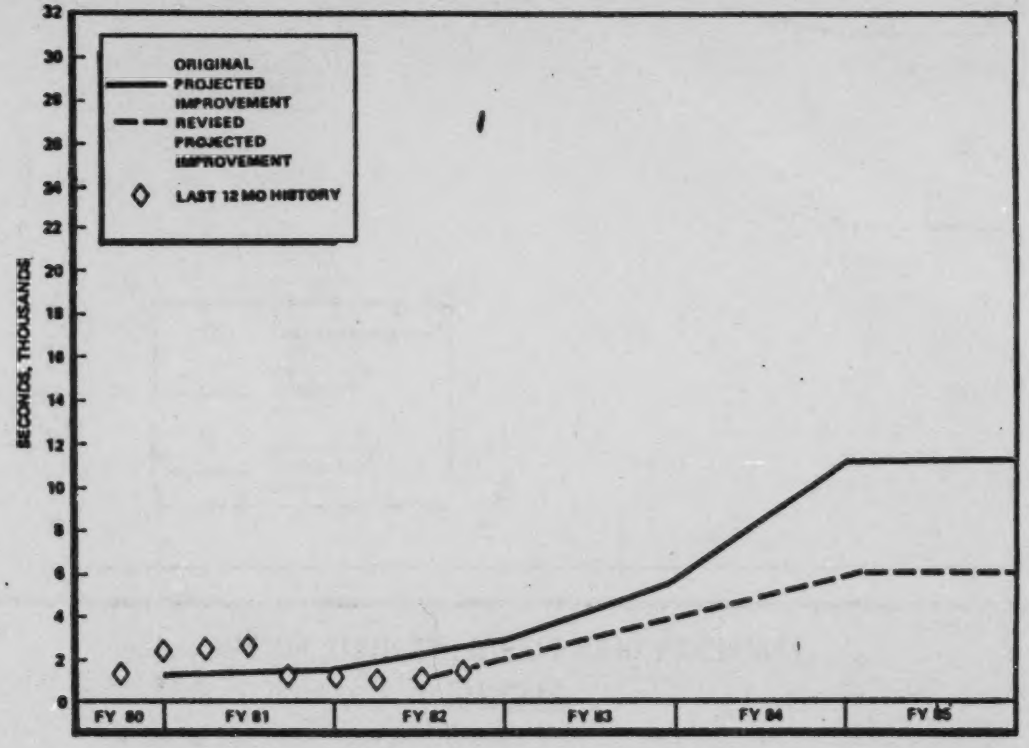
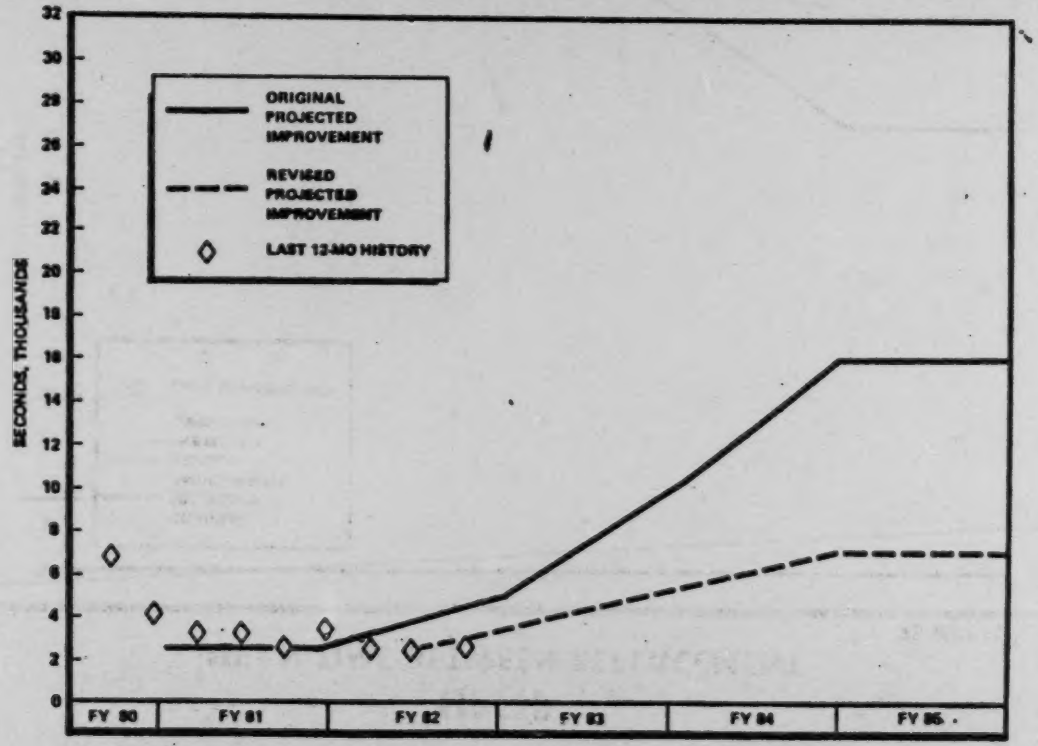


HPOTP
MEAN TIME BETWEEN REPLACEMENT

23 SEPT. 82



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LPFTP

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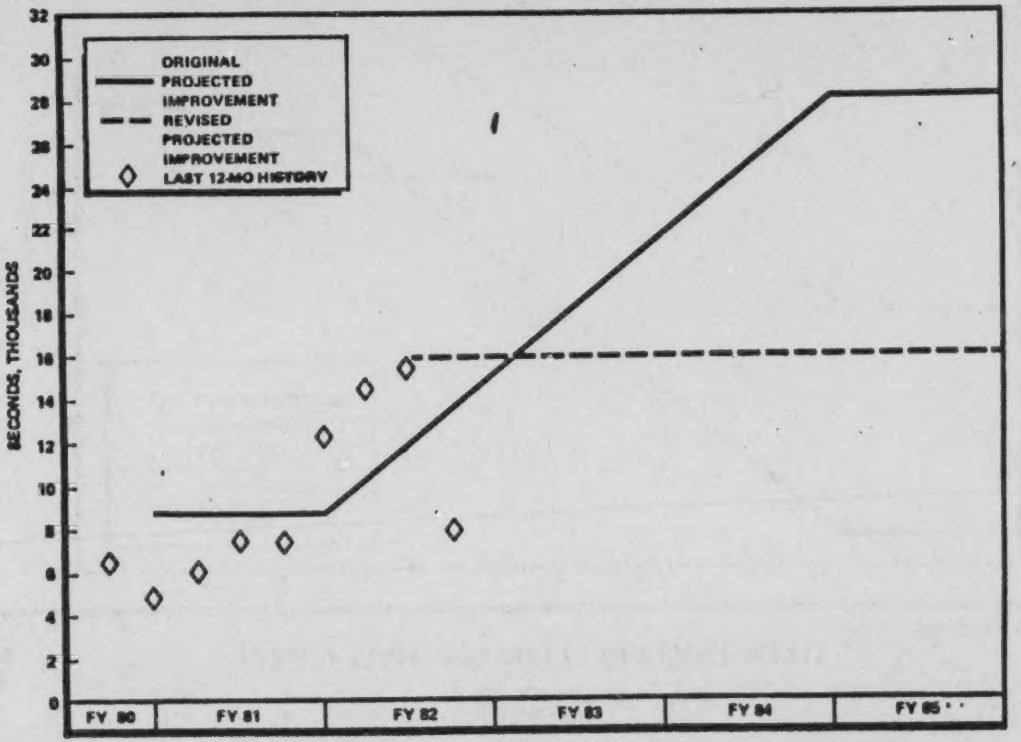

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LPOTP
MEAN TIME BETWEEN REPLACEMENT

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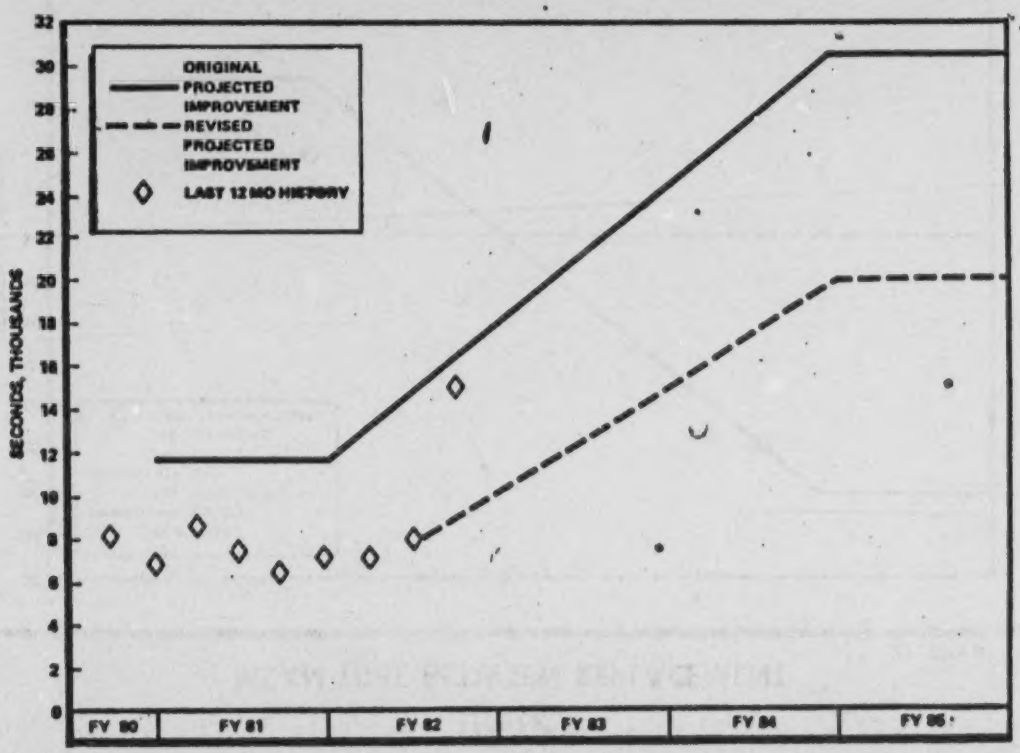

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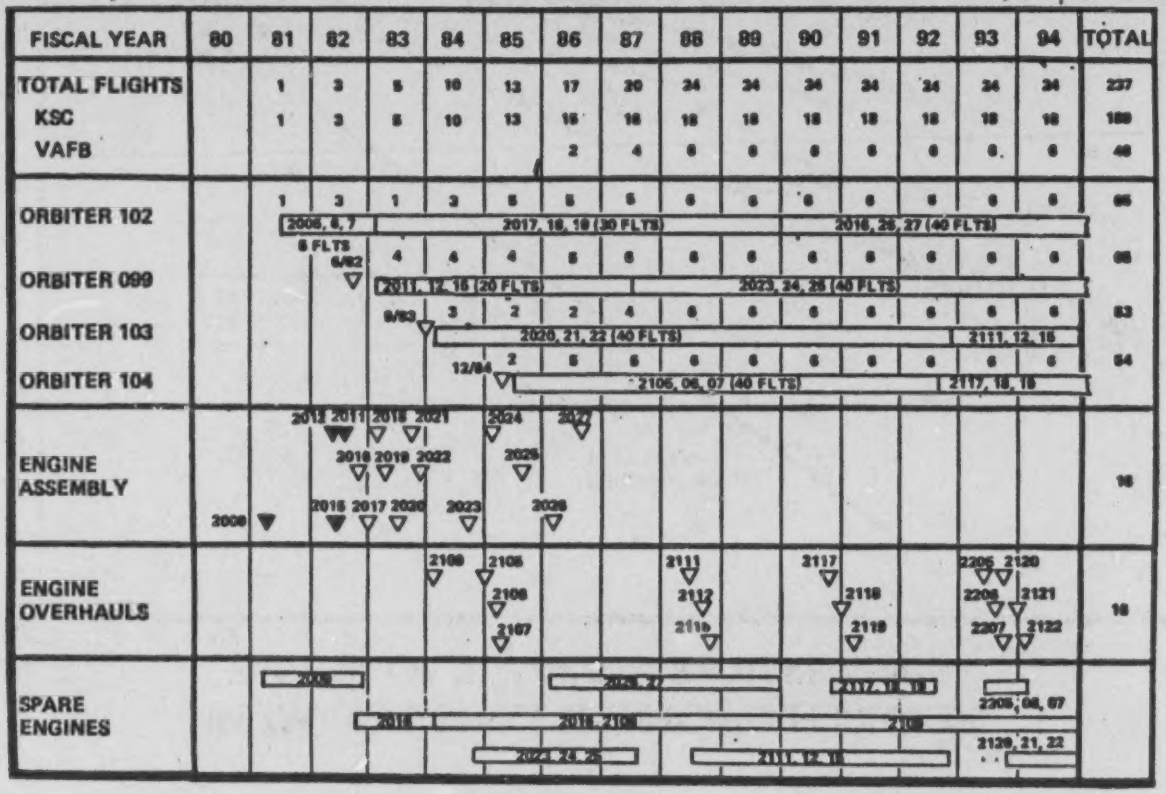
VEHICLE/ENGINE UTILIZATION AND OVERHAUL SCHEDULE

(32 FLIGHTS THRU FY 85-24 FLIGHTS/YR MAX)

POP 82-2

6-18-82



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APPENDIX V

NOTES ON RELATIONSHIPS OF SHUTTLE PROGRAM TO COMMERCIAL AIRLINE LOGISTICS

1. INTRODUCTION

Now that STS-5 has been completed and with OV-099's first flight drawing near, some of the potential problems in logistics, spares and support can be viewed in somewhat clearer perspective. This rather rambling and discursive commentary represents some observations made in the light of extensive airline experience, both in operating and design fields. Some viewponts are undoubtedly contentious and represent only the writer's opinions and not necessarily those of the Aerospace Safety Advisory Panel as a whole.

As in an airline, the relationship of overall safety to logistics and maintenance for a continuously operating Shuttle fleet is absolutely central. It is perhaps more so because the national prestige and multi-million dollar business commitments to established launch dates make it imperative that these will be met in a planned and orderly support manner, rather than by "cannibalizing" and borrowing from the production line. At the extreme end of this launch-at-any-cost spectrum would be the unwise extension of major component overhaul life or the expedient adjustment of operating "red lines."

At some point there must be a transition from the traditional NASA R&D mode to a rational operational pattern but there can be little comparison to that of a safe and successful airline. Some of the issues in these differences will be discussed later, but the major paradox in the Shuttle program appears to be that maximum utilization, amounting to a

projected twenty-two day turn-around (Ref.1) will occur circa 1990 when many of the support and supply sources will have dried up. Even in the so-called "near term" there is an obvious paucity of airframe and engine spares, exacerbatd by the unique nature of the components and the lengthy lead times entailed in ordering and manufacturing them.

2. THE SMALL FLEET

The fleet size of four Orbiter (or five if OV-105 is ever funded) is such that, if any comparison to airline terms were possible, a fleet of say four B-747 aircraft would be considered impractical from the economic viewpoint. About the only way in which such an airline fleet could be made acceptable from the maintenance and support viewponts would be to become a hypothetical part of a larger carrier's fleet of B-747's and to "piggy-back" on those maintenance programs. Obviously nothing of the sort is applicable to the Shuttle programand the airline-Shuttle comparison therefore becomes somewhat academic and misleading. There are, however, some airline control and management techniques which could probably be transplanted with advantage.

Small airline fleets of large, specialized aircraaft depend heavily upon spares pooling arrangements, common engine and major component overhaul facilities, and the like. They have a grand common denominator with other carriers in that the prime manufacturer obtains, resolves and distributes maintenance operating data - especially safety related issues - from all sources. This is reinforced by the regulatory activities of the FAA and thus there are probably more "checks and balances" than could ever be possible with the nature of the Shuttle program. Consequently it would appear that the tightest overall program management control possible will only be just good enough for the Shuttle in the absence of some of the advantages cited.

3. THE DETAIL DIFFERENCES IN VEHICLES

One of the inherent problems of a fleet of vehicles which are almost alike is that it requires special vigilance to avoid the mistakes of apparent maintenance familiarity. For example, in the case of an actual B-757 fleet of the writer's acquaintance there are now, in seventeen aircraft no less than five gross, landing and zero fuel weight combinations, four different engine configurations (all Pratt & Whitney), four different cockpit layouts and it is difficult to find more than two aircraft for which you could use the same wiring diagram manual. The moral to this story is that it is infinitely more difficult to manage systems which are almost alike and this canard applies equally to the four Orbiter OV-099, 102, 103 and 104.

Comprehensive individual wiring manuals are essential, rather than recourse to masses of blueprints to unravel the differences at the flight line or launch pad level. This will become a sine qua non around say 1990 when some of the continuity of the devoted cadre of experts has disappeared through attrition and retirement. Economies in maintenance publications now will reap their own negative reward later, but a format like the airlines' universal ATA Spec. 100 series offers great flexibility in permitting the operators to do their own revisions without the requirement for off-set printing.

4. THE INABILITY TO "BORROW" SPARES

One of the interesting characteristics of large commercial carriers is that, while competing intensively on the traffic route and fare structure fronts, they do, in general, co-operate with each other to a remarkable degree on the maintenance and engineering fronts. The IATP (International Airline Technical Parts Pool) system, initially organized

under IATA airline auspices, is a good example of this highly developed interchange system but its roots are, of course, in the degree of common units and parts between each of the carriers, including the use of each other's engines upon specified rental and return agreement terms. Clearly no such advantages are possible with the unique nature of almost all of the functional system components of the Orbiter and its supporting ground systems, but the purpose of this recital of the obvious is to avoid the danger of making logistics and spares support comparisons which are significantly influenced by airline techniques.

Airline methodology has certainly some lessons which could be of value to the Shuttle program but in this instance it is more likely that military techniques (shorn of some of their traditional overbuying excesses) would provide a better model. The comparatively leisurely utilization rates (in peacetime) would seem to provide a more accurate counterpart from the specific viewpoint of spares, although the length of the supply lines for the Shuttle involve a great deal of expedited special air transport methods - especially critical as turn-around time become shorter.

5. THE SLOW RATE OF MATURING (LOW UTILIZATION)

Since the fleet base of the Orbiters is so small, and the rate of accumulation of hours and cycles so slow it may well be that the entire system will barely attain real maturity co-incident with obsolescence. This problem is intensified by the very low number of test hours compared with the development of a commercial airline and particularly by the absence of a broad "service test" phase among many different operators all around the world. Even so, commercial airlines occasionally suffer disastrous problems at a stage when it

would be reasonable to assume that the entire structure and functional systems had reached maturity. There is also the reverse situation to attaining maturity in which increasing age has uncovered unexpected problems necessitating major remedial programs especially in structural aspects.

Maturity of the SSME will probably be interrupted by the use of progressively increasing power levels necessitated by payload demands. Any support program should guard against excessive optimism in terms of anticipated and uninterrupted linear development of MTBR and MTBF values. The HPOTP and the HPFTP pumps are especially critical in view of their extraordinarily high performance with respect to material temperature limits and operating margins. The complete engine test stand facilities offer few alternatives in the event of damage due to an uncontained failure, which, it would seem statistically is likely to happen with the number of engines in the entire program through, say, the year 1990.

6. THE UNEVEN PREDICTED WEAR-OUT POINTS

The multiplicity of functional components in the Orbiter are at least double and probably closer to triple those in a large commercial transport aircraft. A large proportion of these are of brand new design and it is going to be extremely difficult to rationalize the preventive maintenance programs in terms of MTBR and MTBF to suit. A sophisticated aircraft like the Lockheed L-1011 would probably provide the best comparison but even so most of the functional system components in this case are derivatives of earlier designs and thus there has been a broad historical base upon which to predict an initial maintenance program which could be acceptable to the FAA's MRB - Maintenance Review Board - see Ref. 1) at the outset of operations.

To achieve an equivalent degree of confidence at the

commencement of Shuttle operations is plainly not possible but the vital nature of this data foundation gleaning every piece of experience, test and early use information in a collective and systematic way for the entire system - would appear to be imperative especially in view of production lead times and batch size impoverishment. The magnitude of the task of producing comprehensive FMEA's (failure modes and effects analysis) for all critical components may result in an encyclopedic paper analysis which will be completed too late for economic supplies re-ordering. The judicious use of actual flight-line experience rather than somewhat abstract analyses should therefore be encouraged and some spares procurement gambles made as a form of insurance for the 1990's. Obviously the MEA's for the selected list of critical high-value components must be completed first.

7. DATA FEED-BACK FROM OPERATOR TO PRIME

The mechanism of operating experience data feed-back from the Shuttle operations groups to the prime manufacturers warrants some discussion insofar as it relationship to an airline is concerned. In the airline case the aircraft manufacturer not only collects all his own data from his resident representative upon airframe problems but also acts as a "clearing house" for information on all significant vendor component problems. Some of the larger vendors also have their own representatives at the main airline base. This information chain is constantly endorsed by a lively defect reporting system produced by the airline itself and the whole process is enforced by the sometimes unwelcome attention of the FAA who have their own series of safety related directives and reports.

Parellels of some of the above do not appear to exist in the Shuttle program but, on the other hand, some of the liaison engineering procedures are probably more closely coupled,

especially in the R&D phase. The presence of such large groups of contractor personnel at KSC, for example, at every launch has not parallel in commercial airline operation. In the airline case a small introductory team of factory experts is invariably stationed at the main M & E base for the first few months. These groups include personnel who can help establish the entire maintenance and overhaul programs for the airline operators and assist in securing FAA operating approval if necessary.

Since NASA and the prime contractors appear to act as their own "police force" - there being no counterpart of the FAA - the overall perspective of data reporting requirements may not be as clear as in the commerical airline case. This will be especially true when the craft have been in operation for a decade or more and are considered to be a "mature system." The danger of dedicated channels of information from the larger prime contactor contingents at Kennedy and Vandenberg for the rather exclusive use (even if unintentionally) of the principal factory always exists in a program wherein the manufacturer-operator relationships are manifestly incestuous.

8. THE SPC PHILOSOPHY - STRENGTHS AND WEAKNESSES

The Shuttle Processing Contract philosophy now being developed deserves some comment, particularly because, as a concept it has arrived rather late in the day. Clearly it will not save money as opposed to leaving the processing activities in the hands of knowledgeable and responsible prime contractors. What it can do is to try to makeup for some of the inherent shortcomings of such a small-fleet-base R&D pattern but it must consciously avoid the danger of internecine warfare, especially in information channels. It would appear that since the transfer of experience of the launch techniques must inevitably involve the acquisition of

some key personnel, there would perforce be some "pirating," at KSC in particular. Perhaps this would be necessary eventually in any case to permit NASA to disengage itself progressively from its all-absorbing Shuttle role and move on to other programs.

The greatest inherent weakness in the SPC approach seems to revolve around the extraordinarily specialized nature of the Orbiter and the learning curve issues which are germane thereto. Equipment knowledge and overhaul repair techniques and faciliteis are so specialized and unique that it would seem to be impractical, for example, to every subcontract the support of the SSME's to any group other than Rocketdyne (see Ref. 3). There must be other crucial systems in the Orbiter of the same nature, that is to say, cases in which attempts to transfer authority for apparent contractual advantage would prove unproductive.

9. SUSTAINING ENGINEERING

The somewhat euphemistic term "sustaining engineering" seems to embrace a combination of the function of what the airlines know generically as "engineering" and the manufacturer as "customer support" - or at least the in-service modification and development engineering aspects of support. The tendency among the larger trunk airlines today is to reduce their own airline engineering activities (reductions from approximately 150 persons to 35-50 during the past three or four years being not uncommon) an depend more heavily upon the manufacturer's support engineering services. Top airline management personnel are now more frequently of a legal or financial persuasion and the era of major influence of the key engineering personality has gone (see Ref. 4). Consequently the likelihood of bigger airlines doing their own corrective engineering re-design, as was the case in the early post WW II period has disappeared upon economic

grounds, and the situation may have some sort of applicability to the Shuttle program.

To the outside observer of the Shuttle program it appears that a degree of investigative engineering is being done on both sides of the house - NASA and the prime contractors. In the present R&D phase this is undoubtedly the right course to pursue but when NASA eventually moves into being the operator it would appear logical to keep the corrective engineering responsibility squarely with the prime manufacturer (if their prices aren't too impossibly high!). This field of "sustaining engineering" will be in need of careful delineation of interface relationships under the SPC concept to avoid duplication of responsibilities or worse, abdication.

The commercial transport aircraft is in reality a very complex and therefore imperfect machine made practical to great extent by the skills of the mechanics and technicians who maintain them. This is also true to a somewhat lesser extent for military aircraft, but since the design is almost never optimum the maintenance and operational people have to circumvent the shortcomings by ingenuity and adaptability - a process sometimes known rather grandly as "the learning curve." It is frequently true that there is not, and should not be, a solution to every problem by redesign. Indeed, the smaller the vehicle fleet basis the less practical it is to start upon a redesign in cases where operator ingenuity could alternatively solve the problem. In short, "sustaining engineering" activities should be examined and re-examined and where they have no effect upon safety they should be reviewed through the "pay-back criterion" bearing in mind that nine-tenths of all cost-effectiveness justifications of this type are illusory in the full term.

10. SUMMARIZING COMMENT

If one should be unwise enough to try to summarize such admittedly unsupported impressions as the foregoing, the encapsulation would be something like the following. If nothing else some of the points might provide stimulus for future discussion.

a. The Shuttle program does not appear to have the amount of spares that an airline would require at a comparable period in the opeational development of a new fleet.

b. It would appear that, due to the specialized and unique nature of the Shuttle program more, rather than less spares would be needed, than for an airline.

c. The maintenance publication programs must not be curtailed as a cost-saving expedient - othewise we shall pay for it later in continuous delays and possibly safety.

d. An overall maintenance control program covering all aspects of Shuttle program including the entire propulsion system along the lines of an FAA Maintenance Review Board should be prepared.

e. The Shuttle Processing Contract concept is already late and if it is not to be implemented until the end of 1983 some irrecoverable lead time will be lost. Alternatively, some expedient gambles on spares procurement should be taken by the existing channels now to reduce cannibalization and borrowing from the production line.

REFERENCES

1. "Shuttle Ground Turnaround and Launch Projections" by George Page, NASA KSC October 27, 1982 (at JSC).

2. FAA Advisory Circular AC 121-22 Maintenance Reveiw Board (MRB).

3. Memorandum: Elverum and McDonald to W. M. Hawkins - NASA-ASAP visit to Rocketdyne, Canoga Park, September 29, 1982.

4. "The Sporty Game" by John Newhouse published by Alfred A. Knopt 1982.

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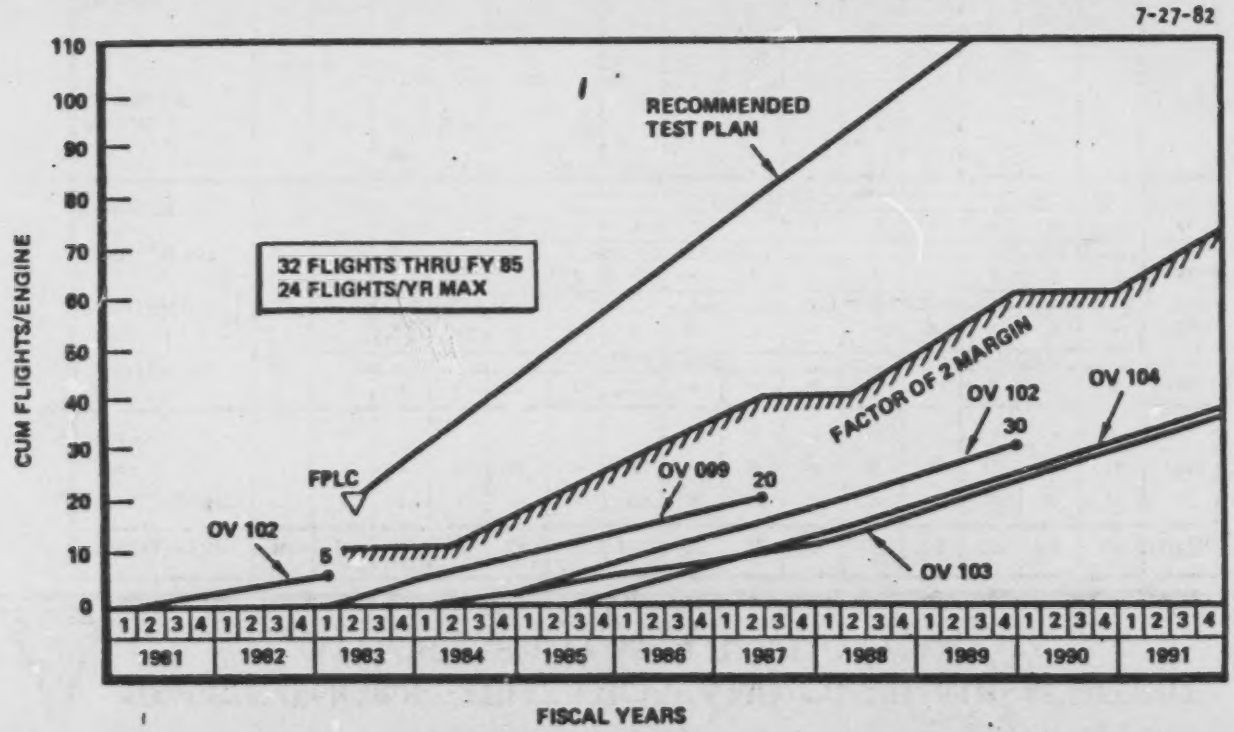
LIFE/MAINTENANCE TESTING PLAN EXCEEDS FACTOR OF 2 MARGIN REQUIREMENTS



APPENDIX VII

Mr. Willis M. Hawkins
Senior Advisor
Lockheed Corporation
Burbank, CA 91520

September 13, 1982

Mr. James M. Beggs
Administrator NASA
Washington, DC 20546

Dear Jim:

During one of the past meetings you asked the Aerospace Safety Panel to review the safety aspects of flight operations at the NASA Centers. Lee Davis of the ASAP accepted the assignment and has now visited Langley, JSC, Ames, and DFRF. His recommendations are as follows:

a. Walter Williams addressed this subject in March. His recommendations are sound and should be implemented, specifically:

(1) Headquarters NASA should update and issue Management Instructions 7910.1 and 7910.2. (The ASAP would be happy to review drafts before official issue.)

(2) The Intercenter Operations Group (ICOG), consisting of the flight operations chiefs should be reconstituted and meet quarterly to exchange information on operational and flight safety problems.

(3) Flight Safety should be recognized as a distinct discipline and experienced pilots should be assigned to

assist the Flight Operations Chief at each Center in fulfilling his safety responsibilities.

(4) Flight Test Engineering should be a distinct and official function at the Research and Engineering Centers. Regardless of the character and duration of any flight program, plans and schedules should be drawn up, preferably by Flight Test Engineering, and approved by approprite levels of management.

b. There should be greater exchange of flight safety related information between the operations branches of the Centers. This could be a function of the ICOG, (2) above. An example, JSC has had several flameouts (some dual) in T-38 operations. Some weeks late DFRF which operates a T-38, had not heard of the problem, or its solution.

c. Line management should be certain that flight safety issues are brought to their attention, and decisions thereon are not based on personalities. Example: The Flight Operations Chief at JSC had recommended a policy forbidding nonstop flights from the Cape to Ellington in T-38s. (Sound reasons: limited range, flameout problems, weather and congestion in the Houston area.) JSC management over-ruled, apparently influenced by the opinions of some of the astronauts.

Davis feels that flight operations at the Centers are in the hands of competent experienced managers. It is clear that the functin of Flight Test Engineering with its planning and judgment inputs would enhance safety margins if the responsibility of assessing risks were assigned to such an organization by Flight Operations managers. Lee Davis specifically commends that suggestion of Williams to your attention. His overall attitude is that no apparent immediate hazards exist but inconsistencies from Base to Base and too-long familiarity with past practices suggest

that new emphasis from Headquarters is imperative along with sincere follow-up.

Very sincerely yours,

Willis M. Hawkins, Chairman
Aerospace Safety Advisory Panel

ORBITER ESCAPE CONCEPT

CONCEPT:

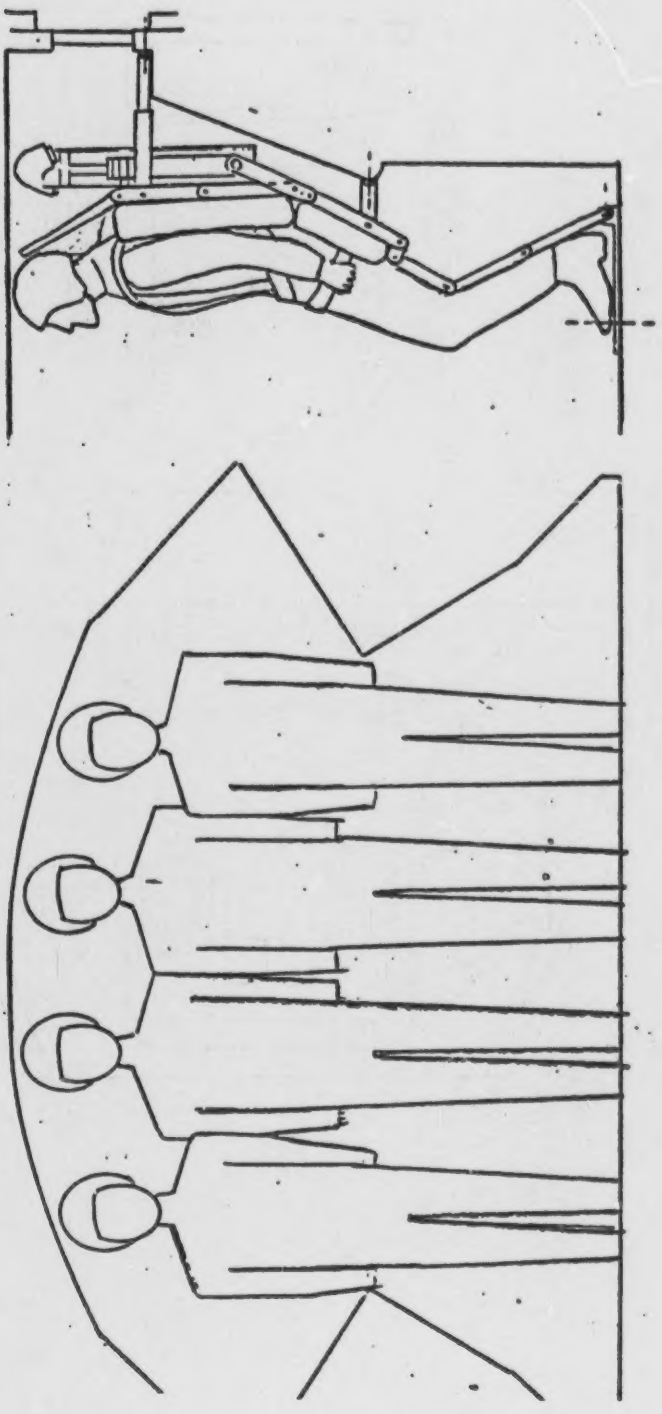
- BASED ON YANKEE SYSTEM DEMONSTRATED IN CA3/B STENCEL SLED TESTS (≈B-66)
- REAR SUPPORTS FLAT ON ASCENT WITH FOLD-DOWN (BICYCLE) SEAT FOR ENTRY
- A PROPERLY DESIGN STRAP SYSTEM COULD ELIMINATE ANY FOLD-DOWN SEAT REQUIREMENT ON ENTRY
- COMMANDER AND PILOT SEATS SLIDE BACK ON RAILS FOR EJECTION ESCAPE
- REAR SUPPORTS FOLD UP FOR STORAGE IN ORBIT
- SEATS/SUPPORTS CONTAIN ROCKETS, PARACHUTES AND STRAP SYSTEMS

OPERATION:

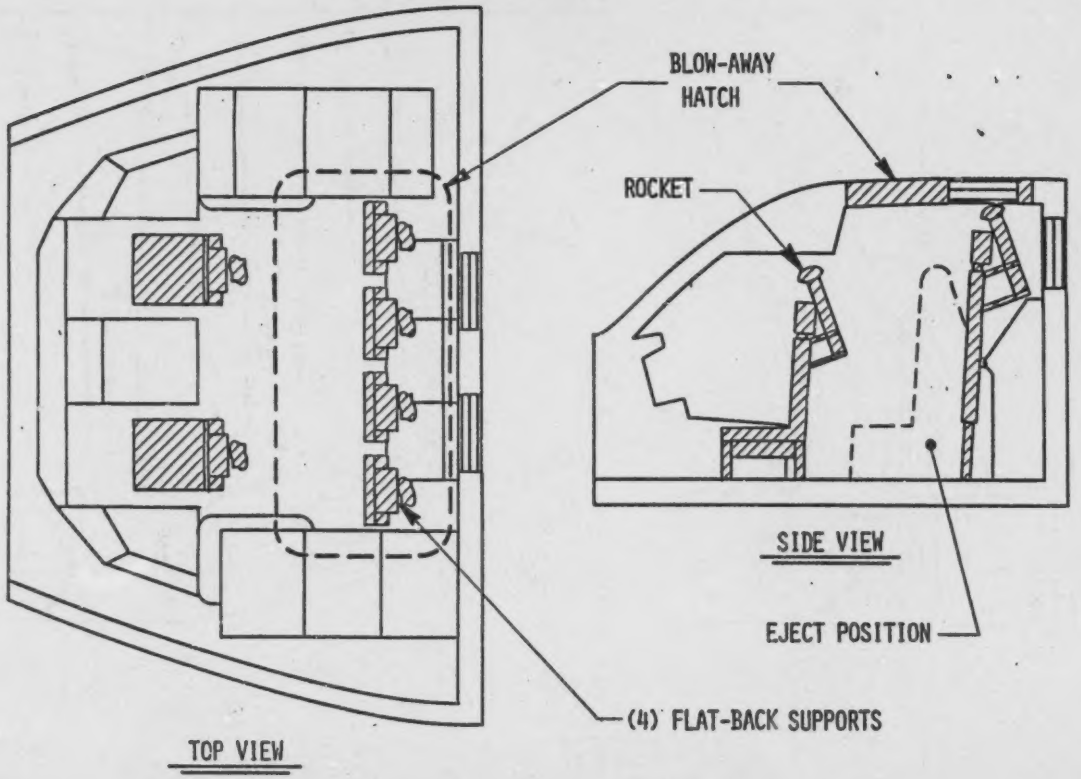
- BLOW HATCH AWAY
- EJECT FOUR REAR CREWMEN
- SLIDE FRONT SEATS TO REAR
- EJECT COMMANDER AND PILOT
- ~2.0 SECONDS OR LESS BASED ON SLED TESTS

BENEFITS:

- FLAT-BACK SUPPORTS MORE COMFORTABLE ON PRELAUNCH/ASCENT AND WITH STRAP SYSTEM ACCEPTABLE ON ENTRY
- ENTIRE ESCAPE SYSTEM (SUPPORTS, ROCKETS AND CHUTES) CONSIDERABLY LIGHTER THAN PRESENT SIX STEEL ORBITER SEATS



ORBITER ESCAPE CONCEPT



STENCEL AERO ENGINEERING CORP. | Talley Industries

RELATED SYSTEMS

AIRCRAFT	SYSTEMS DELIVERED	LIVES SAVED
A-1E	220	30
A-1G	40	
A-I H/J	204	33
T-28	56	17
T-28 MAP	43	
T-28D-10	144	NO DATA
RSRA	6	*
A-300	1	*
LEARFAN	3	*
ENFORCER	3	*
GERMAN FAN TRAINER	100	1/94 DELIVERY

* HAS NOT BEEN USED IN EMERGENCY TO DATE

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SOURCE DOCUMENT, SUBJECT, ITEM No.	RECOMMENDATIONS & CONCERNS	DISPOSITION/STATUS
Annual Report dated January 1983 Flight Safety for NASA Aircraft Ops No. 1	1. Series of NASA aircraft accidents showed need for further emphasis on A/C safety. Pilot error principal cause; attitude governs flight safety. Recommended flight safety education program made up of a series of leadership seminars given by top pilots sponsored by Intercenter Aircraft Operations Panel.	1.&2.: Status as of January 1983---Current NASA Activities are directed to improve accident investigations, independent reviews of center aviation programs, aviation-use policies, Research & Technology Operating Plans (RTOP's), and a greater exchange of aviation safety data. a. Five NASA NMI's (2 on aircraft management, the Intercenter aircraft Operations Panel (IAOP), aircraft airworthiness, and mishap reporting and investigating) are in final processing. b. The IAOP has been reestablished and met in October '82. The IAOP is expected to meet several t_mes each year, subpanels more often, to address and discuss safety and operational issues of significance. c. The NMI's recognize the distinct role for a flight/aviation safety officer at each center. Currently exerienced pilots are assigned to this duty as a collateral duty to advise chief's of flight operations and senior management through an independent feedback loop. d. Before making any firm commitment on flight test engineering NASA will evaluate the recommendations of an independent review conducted by ECO Systems International,Inc e. In addition to the IAOP the first Aviation Safety Officer's meeting is set for April 13-14, 1983 at NASA Hqs. This will be a forum for the timely exchange of safety related information. f. Items "a to e" above have been instituted to assure there is a known, usable information exchange system upon which to base aviation operations decisions. NOTE: Effective April 3, 1983 the Aircraft Management Office was established reporting to the Associate Administrator for Management. The new office raises the aircraft operations activities to a higher and more visible position within the NASA Headquarters structure.
Letter-Report dated September 13, 1982 No. 2	2. Panel recommended: a. NASA Hqs. update and issue applicable management instructions. b. Reconstitute the Intercenter Aircraft Operations Panel. c. Recognize flight safety as a distinct discipline and assign experienced pilots to this area to support flight operations Chiefs at each NASA Center. d. Flight test engineering should be a distinct and official function at R&D flight centers. e. There should be a greater exchange of flight safety related information. f. Line management should be certain that flight safety issues are brought to their attention and decisions thereon are not based on personalities. ...no apparent immediate hazards exist but inconsistencies from base to base and too-long familiarity with past practices suggest that new emphasis from Hqs is imperative along with sincere followup.	

Recommendations & Concerns Inventory

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Panel's Annual Report dated January 1983 Shuttle System Flight & Ground Operations, Mission Activities, et al.	NOTE: See attached letter from the NASA Administrator to the Aerospace Safety Advisory Panel, Willis M. Hawkins, Chairman, dated March 11, 1983. This applies to all items associated with the January 1983 Panel Annual Report. Data supplied in line with that letter may affect the disposition/status as noted at this time.	
No. 1	1. Planning of Flight Test Objectives (FTO's) to define entire flight performance envelope in a timely matter.	1. FTO's are defined in JSC 16725 in a very detailed, updated mode. FTO's are also identified in JSC 07700-10-MVP-11 and as required by other program considerations. They exist for all missions. They are assigned as per Flight Requirements Document 07700-Vol. III; by reviews made by the Mission Integration Control Board; Flight Operations Panel; Program Manager's Requirements Control Board, and other working groups. The end results are the individual flight requirements. To further define the flight envelope a Modular Instrumentation System (MADS) has been added to each Orbiter in support of both defining and obtaining data to meet the FTO's.
No. 2	2. Operational organization must be responsible for sustaining engineering and should control the budget. Examine sustaining engineering roles to avoid duplication, assure sensible interfaces between and at the development centers, prime contractors, and the Shuttle Processing Contractor	2. NASA Hqs and centers continue to move toward organizational structures appropriate to STS operations. This includes the recent Base Operations Contract (BOC) and ongoing efforts toward setting up a single Shuttle Processing Contractor (SPC) for KSC operations. This is a beginning and the Panel assumes further details will be worked out as both NASA and its contractors mature in their operations. Items 4 through 6 below also apply.
No. 3	3. Demonstrate autoland at earliest opportunity with a repeat pilot and a working Heads-Up-Display (HUD) system.	3. Level I Headquarters Program Requirements, dated March 2, 1981, states the Orbiter shall have an autoland system. Level II (JSC) in Volume X of 07700 also specifies autoland with manual landing gear extension and braking. Autoland touchdown demonstration earliest mission appears to be STS-14. The Autoland system has been used in some STS missions to date from about 10,000 feet to 150 feet.

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No. 4	4. The transition of the entire system to operational status in the absence of complete flight confirmation of the Shuttle element performance.	4. NASA recognizing that a 4 flight OFT (test) program was not sufficient to complete flight envelope work continues to use operational missions to do this. Use of the MADS on OV-099 for data collection is a part of this program. Aeroperformance and component characterization are a continuing activity.
No. 5	5. NASA Organization Conflicting factors: a. Residual system development will last until 1987. b. Development Centers are not attuned to management discipline essential to a successful commercial operation due to intercenter competition, reluctance to give up functions, fragmentation of responsibility. c. Severe budgetary constraints.	5. (See number 2 above) Steps are being taken, e.g., BOC & SPC activities and in-house reorganizations to meet the changing needs of "going operational."
No. 6	6. Suggested principles for approach to resolve organization concerns: a. Determine and announce organizational arrangement for managing commercial STS operation even if implementation take a few years. b. Establish management core of this operational organization as soon as possible at HQs. c. Development centers should be subcontractors to operational organization thereby providing development skills/expertise.	6. See no. 5 above.
Logistics, Configuration Control, the Certification Process, Systems Engineering. No. 7	7. Extreme caution be used in decreasing structural factors of safety for weight purposes before all the pertinent flight variations are explored and all relevant data has been analyzed and taken into account. A corollary recommendation is that the Modular Auxiliary Data System instrumentation package be carried until the flight limits are determined.	7. These recommendations are being followed by both the element and systems integration teams. However, there are some areas which have been of concern, such as Orbiter 102 mid-body lower fuselage structure, wing design limits, lightweight external tank at SSME 109% power, filament wound case for SRM, Orbiter aft thrust structure. The OV-102 structure was strengthened, ET non-linear buckling stability analyses are underway and appears to clear it, FWC and wing design limit loads are being reviewed, the aft thrust structure has been analyzed and the assessment positive.

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No. 8	8. Current and future changes must have rigorous certification. Suggest independent organization to set policy and standards and to certify operational procedures and practices. Suggest it be the NASA Chief Engineer's Office.	8. The NASA Chief Engineer has initiated a review of the certification process throughout NASA (not just STS). Intent of this review is to derive recommendations for more timely review of specific areas during development, without imposing additional serial approval requirements on projects. Products include: policy defining items requiring certification, responsibilities and approval process; guidelines for reviews and minimum standards.
No. 9	9. Comprehensive overall integrated logistics plan needed including overhaul and repair plans and facilities, spares stocking and warehousing. a. Maintenance control program for entire system is needed. b. Shuttle Program appears not to have adequate spares on order. Use flight line and launch pad experience to determine spares requirements and order these. c. Restore maintenance manuals, illustrated parts catalogs and wiring diagram manuals. The deletion of these for cost savings will be disastrous and future success is critically dependent upon these items.	9. A number of steps have been taken to achieve an appropriate STS logistics plan and its implementation. A logistics office, reporting to the Director of STS Operation Office has been established, an interim operations period logistics support policy initiated, and a logistics steering working group established. The Administrator has specifically requested the Associate Administrator of Space Flight to consider moving STS logistics to KSC as a part of the SPC activities, looking at the various system used by the airlines, USAF and the US Navy to come up with the best modern system NASA can devise with particular emphasis on timing as they move into the heavy procurement of spares. The Administrator has also asked for a plan for ensuring that appropriate manuals, catalogs, etc., be kept current.
No. 10	10. Review the overall certification process (by NASA Hqs) including flight hardware, software, GSE, maintenance monitoring and also compare current arrangement with original certification process. Determine if current system is really adequate and if not where it needs to be strenghtened. a. Elevate certification policy and deviation approval to Hqs. b. Might look into safety factors for structural critical areas, and material substitutions.	10. NASA feels there are sufficint checks and balances in their testing approach not only for the main engine, but also for the total Shuttle system. The fact that routine testing (Flight Readiness Firing) of a new Shuttle vehicle detected the engine problems on the ground, attests to the validity of the checks and balances for the overall Shuttle system. The Panel insisted upon Flight Readiness Firing for new Orbiter OV-099 and other new ones as they reach KSC. This was stated in Panel letter dated June 23, 1982 to NASA Administrator. However, these engine problems did point out deficiencies in the subsystem testing. Improved techniques were developed for engine leak detection early in subsystems test to avoid the schedule impacts, such

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No. 10 cont'd		occurred on Challenger. In addition, NASA is re-evaluating current techniques for other subsystems as a result of this late discovery on engines. A panel is being assembled with representatives from each Shuttle contractor and each NASA Center to conduct this re-evaluation to assure that all lessons learned will be communicated through the Shuttle community. Also, see item No. 8.
No. 11	11. Configuration Control - Need to assure: 1. identify each vehicle configuration in detail 2. certification status is maintained 3. preclude design changes without recertification.	11. Configuration Management of hardware & software, i.e., change control and interface control, has been receiving added attention at all levels of the STS program - senior management at NASA and contractors have both written policies and assigned personnel to assure proper implementation. A number of "control gates" are used in this endeavor: a design certification review (such as those conducted in September 1982 and January 1983 for STS-5 & -6) the configuration differences are thoroughly reviewed along with their certification status & changes just prior to a mission receive Level I scrutiny.
No. 12	12. Component life determination required to: a. determine safety margins, b. maintain sustaining engineering program, c. make the logistics program cost effective.	12. The determination of "real life" safety margins is an on-going activity using actual flight data (STS-1 to -5 for now) to more accurately define performance/design limits vs. those that were predicted and originally specified. Such work, for instance, is now being done on Orbiter wing loads, TPS thermal loads, SRB and ET thermal protection requirements, etc. Feeding these data into the logistics activity and later into the sustaining engineering effort is being implemented on a case-by-case basis, e.g., Orbiter Line Replaceable Units, TPS modifications, caution and warning system modifications.
Specific Safety, Quality Assurance, Reliability, and engineering aspects of the Space Transportation System. No. 13	13. The Panel recommends the design of new replacement turbomachinery for the SSME that will achieve current required mission life at the full power level. If possible without compromising the achievement of these objectives provisions might be incorporated for future growth. In addition to the procurement of adequate numbers of the current turbomachinery elements, the interim need for spares created by the short life of the current machines at high output must be met.	13. NASA is currently examining the SSME area in great detail as to: mission requirements to operate SSME's at lowest practical thrust levels; increased on-site design reviews (including the "SSME Design Assessment & Test Operations Audit Group"), increased quality control and configuration control; acceleration of engine test program to build confidence in hardware reliability. Redesign of turbomachinery is a longer range objective and may very well result in power levels beyond 109% rated power level now envisioned.

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No. 14	14. A study of a landing gear redesign should be started, one that will achieve an adequate factor of safety with the maximum proposed Orbiter loads. It seems to the Panel that such an effort should include an investigation of changing the attitude of the orbiter on its landing gear. Perhaps using a longer nose gear strut would go a long way toward reducing gear loads.	14. A number of modifications have been made to current gear to strengthen the axles (reduce bending) and brake stators (use clips for additional support). Pilot procedures used to reduce stress include: first application of brakes at roll speeds of 140 kts; vertical touchdown at less than 6 fps, usually less than 2 fps; etc. Tire strength has been improved over the last year. Excessive landing weights usually occur during abort modes (RTLS/AOA/TAL) with the exception of landings with the Spacelab as on STS-9. Resolution of this problem is pending completion of further tests and analyses.
No. 15	15. The Panel recommends that NASA headquarters assure the completion of the remaining simulations and tests of the Orbiter autoland system, including touchdown and rollouts, and if successful, encourage the earliest use thereof.	15. The autoland system during actual flights has been used from about 10,000 ft down to 5,000 ft altitude. The use of autoland in the same manner is expected on STS-6 and -7. Use of autoland to touchdown will be accomplished first at DFRF when personnel and equipment are deemed ready. Also see item No.3 on page 2.
No. 16	16. Problems in pitch control of the Orbiter have been observed since the pilot-induced oscillation (PIO) of the fifth Approach and Landing Test of 1978. Some improvements can be made in software and mechanical controls, but correction of the basic characteristics would require complete redesign; perhaps including the use of canard conrol surfaces.	16. Although there have been some relatively minor problems the present yaw control system has performed in a satisfactory manner. Additional tests are planned during upcoming flights to continue verification of the system. Also see item No. 39 dealing with wing tip rudders.
No. 17	17. With regard to Autoland the Panel suggests: a. A demonstration of the autoland system should be scheduled for a "repeat" commander or pilot as soon as the Heads-Up-Display is ready. b. NASA should reexamine the auto-braking and auto-deployment of the landing gear. In addition include the use of the HUD or autoland in all flights to minimize impacts on the landing gear.	17. NASA agrees that auto-deploy of the gear is a rather simple thing to do and will examine this. Auto-braking appears to be a more complex undertaking but NASA indicates they will look at this as well. The Microwave Landing Beam System (MSBLS) part of the autoland system is being installed at Dakar, Senegal to cover TransAtlantic Aborts. Also see items Nos. 3, No. 15.

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No. 17 cont'd	17. c. Provisions for autoland should be installed at the most likely contingency landing sites, e.g., Dakar, Senegal. d. The investigations of ground control from mission control center for de-orbit should be revisited for possible rescue via automatic de-orbit and remote or automatic control to autoland.	17.c. See previous page 17.d. This question was brought up by the Panel on 9/28/79. The response at that time, 12/4/79 apparently still holds. This response is attached. The Panel requests a "relook."
No. 18	18. The Filament Wound Case (FWC) for the Solid Rocket Motor was reviewed in a cursory manner (one brief meeting). If the plans for the design, development, and testing as indicated at that time are carried out the structural integrity of the final product should be solidly based. Test data is of the utmost importance.	18. The Panel is continuing to review the Filament Wound Case project to assure the stated requirements and their implementation minimize system risks while achieving the desired performance levels. NASA is setting up a Non-Destructive Evaluation (NDE) team based in NASA Headquarters to support the FWC effort.
No. 19	19. The lightweight External Tank - The Panel was concerned about the structural integrity of the ET because: data on strength justification has been sparse; reluctance to depend entirely on linear analytical methods to predict failing instability of a complex shell-like structure subjected to concentrated loads as is the case of the LH_2 tank with design factor of safety of 1.265. The Panel accepts the adequacy of the current analysis and tests for the next Shuttle flight (STS-6), but recommends that the nonlinear analysis now planned be performed to add further confirmation of the adequacy of the lightweight ET before flights that use 109% of SSME rated power level.	19. The concern here was the possibility of ET shell buckling just after SRB separation. It is at this point that loads near the aft end of the ET change from tension to compression due to change from SRB thrust loads taken out by the ET forward of the hydrogen tank to SSME generated thrust loads taken out at the aft end of the ET. The Panel recommended that experts in the field of shell buckling be called in to evaluate the issue. They also suggested that David Bushnell and Bo Almroth be selected for this task. These two prominent experts visited Martin Marietta to evaluate the lightweight ET design and test results. There was agreement that a Factor of Safety of 1.18 above limit load has been demonstrated for STS-6 and subsequent missions for SSME power levels of 104% of rated power. There was a consensus that this is a reasonable margin. It was also agreed that a non-linear analysis would provide added confidence at the higher SSME power level of 109%. These analyses are in process.

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No. 20	20. Reduce and analyze STS-1 through STS-5 flight data to derive actual flight loads vs. predictions for safely exploiting the full structural capability of the STS.	20. Flight data analysis has been and will be a normal function at both NASA and its contractors. Thus they will be able to more accurately define STS mission capabilities (strengths and weaknesses). This is the reason for flight/trajectory expansion in an orderly manner as shown by each missions detailed objectives. Where actual flight loads differ from predictions, the program determines why, makes both analytical and hardware/software corrections. There are some concerns at this time with Orbiter wing loadings.
No. 21	21. To safely explore and establish the structural limits needed to utilize the full capability of the STS some flight instrumentation to monitor critical strength items will be required. It appears that the vehicle best suited to do this is Orbiter OV-102. The following data is required to expand the flight envelope: ascent/entry loads and distributions; payload interaction; cross range/thermal stresses.	21. Orbiter OV-102 retains a very large percent of its development flight sensors and with the use of adequate numbers of Modular Auxiliary Data System modules along with the Operational Flight Instrumentation should be able to provide valuable data to assist in safely widening the flight envelope. Also see Item No. 7.
No. 22	22. Do the Orbiter OV-102 maxi-mod after STS-9 and add the required Modular Auxiliary Data System units.	22. This is in the current plan. See Items 7, 20, 21.
No. 23	23. Lithium batteries and their charactoristics in the many operational modes are not fully understood. Accidents may occur if operating limits are exceeded and quality assurance is not carefully applied during cell manufacture. Protection is provided to control the hazards. However there are undoubtably some applications that are not practical with any other battery. In those cases they should be used with suitable precautions. Their use should be limited to mandatory applications.	23. Lithium-complex cells and batteries used in the Orbiter as well as the LiSO cells used elsewhere have received very thorough reviews by NASA and non-NASA experts. All batteries for STS-6 have been properly cleared as safe. For flight applications beyond STS-6 JSC will certify each lot of lithium cells. Additionally, the JSC staff will work with the special committee established by the Chief Engineer's office to assure continued safe manufacture and use of such cells and batteries. The only application on STS-6 is in the EVA helmet light and CFES experiment. Payloads have been cleared where lithium batteries are used.

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No. 24	24. The Panel recognizes that the design of an all purpose space suit, useful as a work station as well as an emergency device, is not simple but believes that the present design should be reviewed to make sure that it is acceptable. It is not clear that there are major requirements for EVA except in some emergencies or the replacement of failed elements of expensive satellites. It is suggested that an analysis be made for different failure scenarios. Different EVA requirements will undoubtably emerge and such requirements could dictate EVA equipment design requirements.	24. Suit design, particularly pressure level and the mission requirements for EVA continues to be analyzed and reviewed to assure proper support of STS utilization goals and specific payload needs. Current EVA protocols require a 3½ hour pre-breath time with a suit operating at 4.3 psia. Studies continue on methods to reduce pre-breathing time, for example, an 8+ psi suit, reduction in cabin pressure. Future EVA requirements such as satellite and Orbiter repair are under active study. JSC Shuttle program office does not agree on immediate EVA i.e., they do not see the need for immediate egress in case of emergency and indicated they are not responding to this Panel recommendation.
No. 25	25. Space Shuttle Main Engines (SSME's) detailed concerns and recommendations: a. Critical dependence on the turbopumps coupled with mean-time-to-failure concerns suggests that more spares are essential. This would contribute to safety and would preclude dependence on cannibalizing production elements for flight support. b. Not apparent in the planning is the development of a dedicated facility or function for maintenance and overhaul. This will be necessary before minimum safe turnaround time and cost is achieved. c. Shifting turnaround or maintenance responsibilities to a separate organization should be approached with extreme caution. They should be carefully evaluated for their effect on safety.	25. Spares planning is being reassessed in light of the recent operational problems. NASA will make the necessary program adjustments to improve operational support posture when these reassessments are completed. A dedicated overhaul facility has been established, within the Rocketdyne plant, for maintenance and overhaul activities. This facility will serve as a focal point for disassembly, inspection and reassembly operations on recycled components & engines. NASA is developing improved leak testing techniques to be applied to engines both during, and after acceptance testing. These should preclude delivery of an engine with leaks that could cause launch delays. In addition, an operational leak isolation test has been developed for use on the vehicle to better measure leakage between flights.
No. 26	26. Survival during emergency Orbiter/STS operations. NASA should study tractor rocket ejection system and determine the cost to install in a new Orbiter as well as the cost and feasibility of retrofitting current Orbiters.	26. Escape Capability Studies including many different modes of egress have been studied over the years. No one system, at this time, appears to provide "all around" survivability and all systems add weight, complexity and possible hazards of their own (e.g., pyrotechnics, possible contact with Orbiter surfaces). NASA is looking into the use to tractor rocket "pullout" ejection as well as other devices.

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SOURCE DOCUMENT, SUBJECT, ITEM No.	RECOMMENDATIONS & CONCERNS	DISPOSITION/STATUS
No. 27	27. Role of Crew vs. Ground: a. Crews should be encouraged to work toward the routine execution of the entire mission, calling upon ground assistance only in unusual situations. b. The crews must be permitted and aided to develop a reliance on their own capabilities in emergencies.	27. The relationship of on-orbit crew independence to flight experience and STS maturation is not fully understood at this time. NASA does encourage and the crews do conduct mission activities basically on their own. At this time, however with changing crews, learning curves on the up-side, and only a few missions behind NASA the ground support continues at a reasonably high level. Such things as autoland & more crew experience will encourage such independence. Also see No. 5.
No. 28	28. Panel's priority list of Safety Improvements: a. NASA has not studied critical items for safety improvement but has concentrated on performance improvements during the OFT period. b. Concern for safety associated with the APU systems, particularly on the SRB; rudder speed brake mechanical gears and linkage; landing gear system (described before); crew escape for launch, ditching, landing, and EVA systems and desire for quick response capability.	28. a - STS improvement for safety, efficiency and performance has been and continues to be an integral part of both the R&D & operations program. However, at this time it is not readily apparent that safety is being examined with the same intensity. See also Nos. 3, 9, 10, 11, 12, 13. b - NASA agrees that improvements in the APU are desirable. They feel that the existing APU concept will benefit substantially from improvements now being implemented as well as from others now in development. These include improvements in ground servicing procedures and in preventing the migration of hydrazine fuel into the gearbox which results in the formation of contaminants. Also under development is the separation of the fuel pump and gearbox drains. In addition, alternate APU concepts (such as an electric APU) are under consideration for the Orbiter and the SRB's. NASA will review the evolutionary plan for APU improvements in the near future and will make that material available to the Panel. Elimination of the potential single point failures in the rudder speedbrake control system would require a major redesign with very large weight, cost and schedule impacts.

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Panel's Annual Report dated January 1982		
No. 29	29. The Panel suggested that a purely operational organization should be created that would function like an airline or a military mission command as compared to an engineering and development organization. The operational hardware from the development centers much as an airline purchases its transport aircraft, spares, technical support and early training from the aircraft manufacturer.	29. See Nos. 2 and 5.
No. 30	30. The R&D nature of these first efforts, along with the reliance on complex paper systems have nearly obscured the necessity for personal "on the floor" responsibility of supervision at all levels (at KSC) for safety and success.	30. The NASA Administrator requested a thorough review of safety-type accidents and near-misses. At the same time, he has and continues to stress to management at all levels the need to emphasize safe and effective performance on the job. The Agency is committed to rapid turnaround, the achievement of which will necessitate some risks. The Administrator requested the Panel to stay abreast of those risks to determine whether or not they remain reasonable. There have been some changes to improve the personnel situation. KSC will increase manpower to reduce the amount of overtime being worked by the present force. The current POP budget reflects NASA intentions. Rockwell has taken action to have a senior official on duty, on-site, whenever there is testing, modification or processing activity on the Orbiter. NASA Test Directors are on-site whenever vehicle processing is being conducted. The NASA Test Directors notify the senior NASA management officials of all significant events/occurrences during off-shift hours. Plans are being made to have a senior NASA official on duty, on-site throughout all processing activity after Orbiter rollout from the OPF. NASA is also improving the procedures in safety-related areas and being more diligent in following them. New safety monitoring systems have been installed in the aft engine compartment. With the expanded launch team, increased operational management "key" personnel on duty; and improved procedures and safety systems, we can expect a safer operation with fewer incidents and better efficiency. KSC has established a Safety Steering Committee as part of the KSC Mishap Prevention Program, and has chartered a KSC NASA/Contractor Management Safety Advisory Committee. Headquarters issued NASA Standard for "Entry Into And Work in Confined Spaces," NHS/IH-1845.2

SOURCE DOCUMENT, SUBJECT, ITEM No.	RECOMMENDATIONS & CONCERNS	DISPOSITION/STATUS
No. 31	31. Need to streamline procedures and processing requirements for reduced and safe turnaround times.	31. No. 30 above deals with the "people aspect." From a technical and management standpoint, continuing efforts are being applied to: a - reduce ground test requirements by "in-flight check-out and accumulation of experiences, b - reduce paper, e.g., development of new, easy-to-use Standard Interface Document (SID) at KSC and c - introduction of BOC/SPC concepts.
No. 32	32. Many details of doubtful importance are raised to the highest management levels for decisions by-passing the judgment of middle management and clouding the truly important issues that should be defined for major management decisions. The Safety Assessment Report, the Accepted Risk Summary, and the CIL as made available to the ASAP are examples of systems that should be reexamined for simplification and reorientation to identify the issues that truly need top management attention.	32. The STS safety, risk assessment and critical items assessments and documentation have matured during the period from STS-1 to STS-6. For example, the "Mission Safety Summary for STS-6," JSC 18747, is a management-type document, while details are covered and available in day-to-day files of the senior Safety Review Board at JSC, and at appropriate offices at JSC, KSC, MSFC and contractor sites. This includes the very detailed critical items lists for each element of the STS. At flight readiness reviews each element covers hardware/software failures and the Level II safety office provides an integrated picture of relevant hazards and an aggregate risk picture.
No. 33	33. Reliability, safety, and quality organizations should be more clearly in the decision loops and the documentation process appears to be used more for post-operation justification of actions taken than for deciding on readiness.	33. No. 32 applies here as well. Individual safety offices have been strengthened and play an active role in program activities from analyses to hardware/software changes (change control boards) to examination of mission anomalies and failure closeouts. Safety personnel are involved in requirements, design, test and integration activities including audits to to assure proper implementation of S&RQA policies and plans.
No. 34	34. The success of the ad hoc technical audit suggests that the process should be expanded in support of future Shuttle concept changes and improvement programs. It should be considered by any new operations organization to assess routine processes and procedures and suggest new approaches which could save costs without increasing hazards.	34. The full implementation of this recommendation is still to be accomplished. However, such ad hoc teams have been active regarding SSME problems/accidents, e.g., current "SSME Design Assessment & Test Operations Audit," and note the response to item number 30. Similar technical audits have been made for example on EVA/Space Suit Utilization, SRB failure on STS-4, etc.
No. 35	35. Continuing research and development as experience generates either new demands or desirable improvements from a cost or safety point of	35. This has been partially met by the current organization but is part of future operational changes still in the offing. See also item numbers 9, 10, 11, 29 and 30.

SOURCE DOCUMENT, SUBJECT, ITEM No.	RECOMMENDATIONS & CONCERNS	DISPOSITION/STATUS
No. 35 cont'd	view must provide a formal channel to allow the operational organization to call upon NASA's R&D elements for necessary work essentially on a subcontract basis. This suggestion that the operations people look to the scientists/engineers for R&D is coupled with a similar recommendation that the R&D community of NASA look to the operations people for the performance of transportation and operations tasks for all of NASA.	
No. 36	36. Plan an orderly R&D and certification program system improvements to create a more nearly optimum operational system (incornorate in future Orbiters or retrofit). This because it is recognized that many of the significant system changes previously suggested by the ASAP and those recommended in this report will not be feasible for retrofit in the present Orbiter production series. Therefore a number of present systems will require more continuing special readiness attention for each mission than revised systems designed to be optimum for routine operations.	36. These are discussed under previous items numbers 7-12. This also includes the previous discussions on page 23 "STS Flight & Ground Operations, Mission Activities." This is also apart of the SPC concept. There are a number of "turnaround" and "enhancement" working groups (actively engaged in working problems associated with safely reducing turnaround times. These are chaired or co-chaired by JSC, MSFC, KSC with membership from both NASA and the contractors. Examples include "Shuttle Turnaround Analysis Group" (STAG) and "Shuttle Turnaround Enhancement Program (STEP). Logistics et al was a major topic covered by a management meeting conducted at KSC in November 1982.
No. 37	37. (Logistics) Maintenance and overhaul plans must first be developed in detail for KSC and VAFB and then, using these, such logistics elements as supply, manning, training, publications, and vehicle standardization can more logically fall into place. A range of turnaround rates should be considered from the most optimistic possible grounding of one vehicle due to accidental damage or modification.	37. See No. 36.
No. 38	38. (Logistics) The ground support equipment and requirements have no parallel in previous practice and matters affecting overhaul and in-service life arising from repeated launch degradation are in need of special study now. Until this most comprehensive planning is undertaken it will be	38. See No. 36.

SOURCE DOCUMENT, SUBJECT, ITEM No.	RECOMMENDATIONS & CONCERNS	DISPOSITION/STATUS
No. 38 cont'd	difficult to maintain budgetary control in a program which has now to be very cost-conscious. Schedule reliability is the sine qua non to attract commercial and even military payloads and, in the view of the Panel, is more likely to be affected around 1983-85 by parts shortages than by equipment or design failures.	
No. 39	39. Covered the following additional items: a. Crew provisions, instrumentation, and workload. Concern with what appears to be unnecessary complexity in the cockpit instrumentation and the facilities for the crew to function at the highest efficiency for the total mission. When additional personnel are aboard the vehicle this situation will increase our concern for safety of the additional passengers. The extensive training and selection process has produced crew members who are substantially more capable than can be expected to be available for the life of the program. The Panel believes now is the time, rather later, to make improvements to account for longer missions with added crew members and passengers who may not be as perfectly tuned as have our earlier pilots and commanders.	39. a - Improvements in the STS have and will continue to decrease pilot workload and system tolerance to error. Example of such improvements are the heads-up display, the test and graphics uplink system, increased automation, and reliability improvements. NASA initiated a general study of improvements to crew accommodation and livability and intends to continue to make improvements of this type as problems are identified.
	b. Proposed use of tip rudders on the wings to enhance safety through better aerodynamic control.	b - Although there have been some relatively minor problems, the present yaw control system has performed well. LaRC is studying the potential use of wing tip rudder on the Orbiter but NASA does not believe wing tip rudders are required on existing Orbiters. However, their use would be reconsidered should future missions show the need.
	c. Thermal protection system improvements such as Strain Isolation Pad (SIP) changes.	c - The present SIP system has been certified for operational use by extensive analysis, numerous ground tests, and aircraft flight tests. The ground testing included tests for 100 mission duty cycles and severe environmental tests for critical locations. Based on this, NASA does not believe further development of the new oriented fiber SIP is warranted at this time. We are in process of evaluating SIP extension and stiffness characteristics measured during OFT.

SOURCE DOCUMENT, SUBJECT, ITEM No.	RECOMMENDATIONS & CONCERNS	DISPOSITION/STATUS
No. 39 cont'd	d. Suggestion that when experience dictates major changes in systems it is hoped that a more consistent "redundancy philosophy" will begin to emerge, for such items as: hydraulic system architecture, multi-wheel main gears, proper closure signals for the locks on the payload bay doors, multi-path controls for the remote manipulator system (RMS) all to enhance operational safety.	We are also revisiting the SIP lifetime issue and reviewing our procedures to insure the SIP does not unacceptably change dimension with time and repeated exposure of the missing environment. Should the results of our OFT evaluation and our SIP lifetime review indicate the desirability, development of the oriented fiber would be reconsidered. d - Also see No. 41 below. Systems and element reliability analyses have defined the hazards/risks involved in the many critical areas of the STS and are redundancy. Management is inconsistent, e.g., 3 Orbiters APU's, single flight control surface actuators, dual landing gear deploy mechanisms, etc. However, these designs are based on experience, failure rates, and such. NASA will continue to review the redundancy as dictated by operational experience.
Panel Letter Report dtd June 23, 1982 No. 40	40. Flight Readiness Firing prior to STS-6. The Panel stated that all the reasons for an FRF prior to STS-1 were still valid for STS-6 and the Panel recommended an FRF be included in the STS-6 processing schedule.	40. This recommendation was fully accepted by NASA and the Administrator. The FRF prior to STS-6 was conducted and resulted in mandatory modifications to achieve a safe mission.
No. 41	41. Conduct a major audit of the concept of redundant systems as applied to the essential elements of the Shuttle.	41. See also No. 39d. This has been discussed with the Panel at a number of their fact-finding sessions at both NASA and contractor sites.
No. 42	42. Establish a plan for continued performance envelope expansion to improve STS operational utility (requires going beyond the current 4 flights envisioned for the STS Test Program).	42. See Nos. 44 and 47.
No. 43	43. "Redline" (Max/Min limits on flight/ground parameters applied to such items as temperature, pressure, etc.) limits should be set, and presumably have been, by combining accumulated experience of both design and safety engineers. To override such judgment in the launch environment potentially introduces risks. This should be avoided in any case and must be for any operational mode. "Redlines" should be reassessed and then a rigid "redline" discipline must be achieved.	43. Ground test launch preparation and flight experience are the real determinators of "redline" limits. Redlines are reassessed prior to each mission and NASA fully expects, where STS missions are more routine, to modify few such parameters. When, in the past, redlines have been overrided it has been based on sound technical judgment and an assessment of possible risks. NASA will continue to closely monitor both setting and the use of redline values.

NASA

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National Aeronautics and
Space Administration

Washington, D.C.
20546

Office of the Administrator

MAR 11 1983

Mr. Willis M. Hawkins
Chairman, Aerospace Safety Advisory Panel
Lockheed Corporation
P.O. Box 551
Burbank, CA 91520

Dear Willis:

We are in the process of reviewing your Annual Report. I understand you and Herb are planning to get with Jim Abrahamson's program and project people after the STS-6 mission to discuss the Panel's conclusions and recommendations so that we have a full understanding of both the scope and significance of your concerns. After these discussions, we intend to provide you an interim response in May and a final one in July. I hope you find this acceptable.

I want to thank you and your fine Panel again for the wise counsel and advice which is significantly contributing to the continuing success of the Space Shuttle.

Sincerely,

James M. Beggs
Administrator

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas
77058

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Reply to Attn of MG-79-L210

TO: NASA Headquarters
Attn: MH-7/Director, Space Shuttle Program

FROM: LA/Manager, Space Shuttle Program

SUBJECT: Response to Uplink Concerns Expressed in the Aerospace Safety Advisory Panel (ASAP) Report of September 28, 1979

The ASAP, in its September 28, 1979, report to Dr. Frosch, expressed reservations about the Orbiter onboard capability to lock out ground uplink commands. The purpose of this response is to explain how and why the current uplink design evolved and what has been done to avoid unwanted loss of uplink capability.

The Orbiter design includes a hardware switch to enable or block uplink. Initially it was anticipated that, with few exceptions, civilian missions would be flown with uplink always enabled. By the end of 1978, however, it was established that all missions would exercise some form of communication security. For operations phase TDRSS communications, electronic security coding will be provided. For earlier missions, the Orbiter has implemented a combination of crew procedures and onboard software to block uplink when the Orbiter is not in range of an appropriate ground station. The software was designed to minimize the crew workload and sleep constraints which would be imposed by use of the hardware switch for extended on-orbit operations. This was done by providing (in the on-orbit software configuration) a crew-controlled "software switch" which can be selected as "AUTO," "ENABLE," or "INHIBIT." "ENABLE" and "INHIBIT" cause the software to unconditionally "ACCEPT UPLINK" or "REJECT UPLINK."

The "AUTO" mode uses the system management computer's knowledge of ground station coverage geometry with respect to the Orbiter. At times when stations are predicted to come into view, the software is conditioned to enable uplink; and when it is calculated to go out of view, to reject uplink. Selection of "AUTO" will be verified by the crew and confirmed by the ground as part of the pre-sleep procedures. As further insurance against prolonged loss of uplink during sleep periods, the ground will issue SPC's (stored program commands) to the caution and warning system audible alarm. An SPC is a command with a specified activation time. In this case, it functions as a ground-controlled alarm clock. On each successful station pass, the ground will normally reset the SPC to a time

prior to the second subsequent station pass. If, on the first subsequent pass, uplink is unsuccessful, the SPC will not be updated and thus it will be activated and alert the crew prior to the next station. Once alerted, the crew will attempt to find and correct any onboard system problems. If this is unsuccessful, voice communication with the ground will be used to update critical data (state vectors, targets, etc.) and establish subsequent mission plans. Voice is provided by two S-band channels (which share some circuitry with uplink) and an independent UHF channel.

Software control of uplink is not available in the ascent and entry computer programs. During ascent and entry, the crew will use the hardware "BLOCK/ENABLE" switch to maintain the required uplink configuration.

In summary, the current uplink design evolved in response to requirements for uplink security. The system has been designed to provide uplink during periods when valid communication is available; however, the design is predicated on proper procedures and is subject to human error. Extensive crew training and integrated SMS/MCC simulations should reduce the risk of human error to an acceptable level.

Robert F. Thompson

cc:
SAMSO-Los Angeles, LV/D. R. Collins (NASA)

Preliminary Plan

GLOBAL RESOURCES INFORMATION SYSTEM (GRIS)

1. SUMMARY

This preliminary program plan for a Global Information System (GRIS) has been prepared in response to Congressional direction that NASA develop a plan for an interactive network to help solve such global concerns as threats to the ozone layer, the carbon dioxide problem, air and water pollution, and mineral and energy exploration. Specifically, this project plan covers development and implementation of the prototype network communications, data systems technologies, and information processing techniques required for an interactive data network such as GRIS.

The GRIS project, were it to be undertaken, would represent a significant long-term commitment by NASA and other government organizations, involving costs of $30-45 million over a 7-year period, to acquire the necessary technologies, data management approaches, and information processing techniques. NASA would work with other agencies, such as NOAA, DOI, to insure access to the full spectrum of data needed.

The GRIS would be a new initiative, for which no funding exists in the current budget.

2. GOALS AND OBJECTIVES

The overall goal of the GRIS program is to develop a widely distributed interactive network that allows researchers in earth, atmospheric, climatic, and oceanographic sciences to access and process global resources data sets, including development of data system techniques and algorithms needed to derive useful resource information. This would be accomplished by the first developing and adapting the basic computer science technologies required for distributed data base management, global networking, data integration, data processing, and information presentation.

Activities under the program would include coordinated planning and concept development between the earth resources and computer science disciplines to identify specific resource data sets to be utilized, and requirements for technology applications and evaluations. Detailed planning and design would result in specifications for competitive procurement of needed commercially-available services, and technology development activities conducted through the NASA centers.

3. PROGRAM MANAGEMENT AND INTERAGENCY RELATIONSHIPS

A lead agency would be designated by the President, and interfaces would be established with other government agencies as well as international organizations to develop a broad planning and implementation base and to develop a framework that would facilitate participation by these agencies in the development and use of GRIS.

Specifically, mechanisms would be developed to share data and software with the National Oceanic and Atmospheric Administration and the Department of the Interior. Also, data standards and protocols would be developed in conjuction with the National Bureau of Standards and international standards organizations. Ready accessibility of global data sets from interagency and international sources, and mutual sharing of data system capabilities, would be major objectives of the GRIS program.

4. RESOURCES

The following table identifies a preliminary estimate of the resources required for the GRIS Program. As system design candidates and alternative technology development programs are developed, this resource estimate will be updated. Note that resources beyond those needed by NASA to support GRIS are not included. Subsequent operational resources will be planned by the responsible operating agency, and estimates for those resources will be identified towards the end of the implementation phase as a part of operational planning.

	YEAR 1	YEAR 2	YEAR 3	Balance to Complete	Total Estimated Cost
Millions of FY 84 dollars	3	6	8	13-28	30-45

It should be recognized that GRIS is a technology-base project, designed to develop, implement and evaluate a variety of data system and networking approaches to support research on global issues. As such, the desired data access and processing capabilities will be implemented for some, but not all, of the data types involved.

5. PROGRAM DESCRIPTION AND SCHEDULE

The GRIS Program would be carried out in distinct phases, consistent with sound management practices. As the program definition matures, some of the development and evaluation phases may overlap. Appropriate management requirements and procedures would be applied to these sub-phases as necessary.

A) Definition Phase - The initial activities in the Definition Phase would be concentrated on defining the program in terms of specific research objectives to be accomplished to provide a focus for the system design. A definition team, which would include science discipline representatives, computer technologists, system engineers, and program managers would be created to address specific aspects of the program. The definition team would formulate the program's research objectives, identify data sets to be incorporated into GRIS along with their current location and status, and set forth the requirements for system capabilities in terms of data access, processing, display and user support (e.g., electronic messaging). In addition, the definition team would identify suitable technical approaches to satisfy the requirements on the system.

As needs for new technology are identified, development programs would be defined to bring that technology within research of the GRIS implementation. The Definition Team would also explore the transferability of technology under development for commercial and military applications for use in GRIS.

During the Definition Phase, candidate system architectures would be developed as strawmen designs against which to evaluate requirements and technologies. Program management, science and system engineering personnel would work with other agencies (e.g., NOAA, DOI in considering alternate approaches, non-NASA data bases, and existing capabilities that might be integrated into the system throughout an appropriate development period.

B) Implementation Phase - Following requirements definition and development of program plans, detailed science and engineering planning would be undertaken to develop the specifications for competitive procurement of commercially available capabilities and services (e.g., common carrier telecommunication systems). Detailed schedules of planned procurements and development activities would be prepared, and integrated with plans for incorporation of existing NASA pilot resource information systems, other agency systems, and the various data bases. The incorporation of existing systems and data bases may be accomplished by a full scale integration into the GRIS program, or be establishing interactive mechanisms that provide the needed capability. Programs to carry out approved technology development, and planned procurements would be initiated by appropriate NASA program offices through NASA centers.

As the system concepts develop, the definition team would identify those technologies that are necessary to provide the capabilities needed. Many of the technologies necessary for a cost effective implementation of GRIS (e.g., low cost microprocessor based work stations, common carrier data networks, etc.) which were unavailable just a few years ago, are now available. The GRIS would take advantage of data system technology concepts being developed and demonstrated within the Information Systems Office since 1979. In addition, the Definition Team would explore the possibility of transfer of technology from commercial and military development efforts.

Continuing coordination with various Federal and foreign agencies would be required to establish agreements, standards, protocols and charging mechanisms to bring into the system the various data sets from remote sensing spacecraft and ground and aircraft observations. Achieving this federation of data sets would involve both technical and management attention.

After successful verification of system capabilities involving researchers in pursuit of global concerns, data bases and processing facilities within NASA and U.S. universities, the configuration could be expanded to include broader participation in the U.S.; and, through coordination with Department of State and foreign agencies, to incorporate foreign users and data sources. The final system verification would be performed by the program scientists using the system to perform the specific research tasks specified in the Program Plan. Satisfactory performance of the system in that application would constitute the completion of the GRIS Program development.

C) Operational Phase - As GRIS matures, the GRIS Program would gradually diminish to a standards maintenance and network management activity. Users would be encouraged to use commercially available telecommunications and information processing services. The Operational Phase of the GRIS Program would commence with the transfer of the system to an organization appropriate to maintain and operate GRIS for on-going scientific research in support of the earth science disciplines. Planning for this transfer, and establishing the necessary agreements with the involved agencies would be begun during the Definition Phase, and completed during the Implementation Phase.

SOURCE DOCUMENT, SUBJECT, ITEM No.	RECOMMENDATIONS & CONCERNS	DISPOSITION/STATUS
No. 44	44. Review specific systems which can be improved by redesign or design modification: a. Landing gear b. Cockpit and crew station design c. Orbiter tile SIP material improvement d. Flight control actuation by single actuators e. Use of non-hypergolic propellants for the APU and RCS/OMS propulsion systems	44. a. See No. 14 b. See Nos. 27 and 39a c. See No. 39c d. See Nos. 39d and 41 e. See No. 28b
No. 45	45. Recommended studies and redesigns should be established as an overall program for the improvement of the Shuttle and its further development as an operational system.	45. The screening process that will be used to implement candidates as the budget becomes available: a File will be maintained on all reasonable candidates to enable assessment of the total known potential improvements available in each of the following prioritized categories: - improved safety - reduced cost to operate - increased flight rate - increased performance capability A file will also be maintained on all the approved and disapproved candidate improvements. The improvements office will also prepare periodic briefings to the PRCB/CLRB on the ranking process, candidate recommendations, and other information of interest related to improvements. The candidate improvements will be classified as follows: - General: adequately understood to initate the change paper for approval to make the change. - Design Packages: a study or design work is required to determine whether or not a change feasible and cost effective. - Block Change: cannot be incorporated into the operational hardware as a kit, or during a minor modification. - Technology/Development: basic development is required to determine if the concept can be made to work.
No. 46	46. The STS Readiness Review Process - a. Reliability, safety, and quality groups should be more clearly in the decision loops;	46. The STS review process includes numerous ad hoc, one-time, and formal reviews during the processing

SOURCE DOCUMENT, SUBJECT, ITEM No.	RECOMMENDATIONS & CONCERNS	DISPOSITION/STATUS
No. 46 cont'd	b. Documentation used for summarizing risk and evaluation of readiness need simplification and reorientation to identify the issues that truly need top management attention; c. Need to have an "operations group" independent readiness assessment.	for launch. They culminate in, at this time, reviews which include the Administrator, Deputy Administrator, USAF, customers/user's of the STS, and other senior management plus backup by technical personnel. Although the documentation is thorough there still is a feeling that S,R&QA is not as fully in the loop at all sites (NASA & contractors) in an integrated fashion, i.e., all segments of the Safety, Reliability and Quality Assurance community do not fully communicate as evidence by FRF/SSME difficulties.
No. 47	47. Past success with the use of ad hoc technical audit working groups suggests that the process should be expanded in support of future STS concept changes and improvement programs. Success of such ad hoc teams stems from the currency of their technical or operational experience, their total familiarity with the system and their lack of dedication to any routine reporting or documentation discipline.	47. See No. 36.
Panel Letter Report dtd November 29, 1982 Late Review of hazards and issues No. 48	48. The Panel was concerned about the lack of a process which brings added hazards to their attention (and the attention of others within NASA)	48. Data on the processing of the heat exchanger indicates that the leak was due to a weld defect, not detected during fabrication. Special tests have been devised and applied to Challenger engines to assure that similar defects do not exist in these engines. Several improvements were incorporated in the heat exchanger processing in 1977 and 1980 to improved the welding process. Unfortunately, these actions were implemented too late to catch the problem on Engine 2016. All current flight engine will have heat exchangers with the improved processing. The Aerospace Safety Advisory Panel has been advised of, and has participated in several telecons addressing the heat exchanger leak.
Panel Letter Report dated June 3, 1981 No. 49	49. Instrumentation recorders should be redundant to assure adequate data availability after flights.	49. The DFI-PCM recorder that failed during STS-1 was replaced for STS 2 plus subsequent. The crew can use a jumper cable to the ascent recorder to serve as a backup. A permanent wiring change was made for STS-3 and STS-4 to provide for remote switching of recorders in the event of failures. Redundant units have been installed on OV-099 and will be on OV-102 and subsequent units.

SOURCE DOCUMENT, SUBJECT, ITEM No.	RECOMMENDATIONS & CONCERNS	DISPOSITION/STATUS
No. 50	50. During preparation for STS-1, it was found necessary but undesirable to work on the Orbiter with hypergols loaded and only a single valve in the line. This should be corrected and if it cannot prior to STS-2, the same elaborate safety precautions should be instituted.	50. Regarding the safety of the Orbiter with only the single thruster valves keeping propellants from the ground personnel, STS-2 used the same safety precautions. A primary thruster valve redesign study has been conducted. The redesign should solve the present valve's "burp/bounce" and leakage problems. If FY-82 enhancement funding to start development and qualification of the new valve were available, production valves could have been available for OV-104 and retrofit on OV-102/099/103. However, this improvement was not funded. Therefore, these valves will have to be retrofitted on an as available basis. The use of this new valve will enable the Orbiter to keep an upstream isolation valve closed thus providing a series redundant propellant shutoff capability on the ground.
No. 51	51. There were certain items in the Shuttle certified only for STS-1 and not beyond. We assume that these are being looked at in light of the flight experience and the certification extended, or that additional testing is being done.	51. A significant effort was devoted to close out certifications for STS-2 and beyond. These were tracked and reported on a monthly basis. The Panel was updated at NASA centers on the preparations for each flight. Extending missions life of all STS ground & flight components continues and is a part of every pre-mission review as well as such long term effort as STS logistics.
Panel Letter Report dtd August 12, 1981 No. 52	52. Software architecture should be examined and if necessary should be restructured so that a common set of software can handle most flight operations with only minor I-load changes.	52. NASA has achieved a high degree of S/W stability for the latest STS missions. Patches are still being made as dictated by hardware and mission requirements. Software release No. 19 was used starting with STS-5 and will be used through STS-8. STS-9 and subsequent missions will use release No. 20.
Panel Letter Report dtd October 29, 1981 No. 53	53. An extra hazard, to be avoided at all costs, is that changes made to the software and hardware close to a launch will not get the safety scrutiny that they deserve.	53. Configuration controls have been and remain on all hardware/software changes at all times and particularly close to launch. Policy and program directives as well as lower level program written direction to this effect continues to be implemented. Controls move to higher levels of management as launch processing progresses.

[EXCERPTED FROM PAGES (IX)-(X), UNITED STATES CIVILIAN SPACE POLICY, SERIAL C, APRIL 1981]

CONCLUSIONS AND RECOMMENDATIONS

1. Successive administrations have failed to establish long term goals for the civil space program.

2. This lack of goals has been responsible for an indifferent attitude on the part of the public. The circular argument has then been made that there is little public support for space goals.

Recommendation: NASA should propose to the Congress a set of long term goals which will reflect a balance between space science, applications, and space transportation activities. NASA should strengthen the agency-wide planning process.

3. Lessons learned from the Apollo and Space Shuttle programs that can be applied to future programs include:

A. Space programs benefit from vision, leadership and continuity of commitment.

B. Post-development "dividends" cannot be counted on as the source of funds for deferred new projects.

C. When funding profiles for large programs are manipulated for political reasons, the programs cannot be expected to operate at optimum efficiency.

4. Failure to exploit the Apollo and Skylab experiment through the establishment of a permanent presence in space and the upcoming hiatus during which no imaging data will be returned from other planets via United States spacecraft reflect a national loss of vision, leadership and resolution.

5. Commitment to a major, high-challenge space engineering initiative is both technically feasible and desirable.

Recommendation: The Administration should commit to a major, high-challenge space engineering initiative. One candidate initiative is a manned, multi-purpose, open-ended space operating base in low earth orbit.

NASA should reaffirm the Nation's commitment for continued exploration of our solar system through intensive investigation of other planets including a Mars sample return mission.

6. Solutions to many global concerns such as threats to the ozone layer, the carbon dioxide problem, and global air and water pollution, as well as global mineral and energy exploration would benefit from the existence of a Global Resource Information System. A system tying all the relevant data bases into an interactive network would likely be superior to a single organization responsible for acquiring and holding all the information.

Recommendation: NASA should submit to the Congress within 12 months a preliminary program plan for a Global Resource Information System utilizing an interactive network of relevant data bases including program scope, technology needs, and resource requirements.

PROGRAM PLAN FOR

ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE (ACTS)

1. Introduction

NASA's space communications program was restructured in early 1982 to emphasize the high risk technology required to ensure continued U.S. preeminence in the important field of satellite communications. These changes improve the program by broadening its applicability to the entire spectrum of satellite communications and restricting its activities to only high risk, long lead technology development which industry cannot finance. As a result, the experimental satellite system to be sponsored by NASA focuses primarily on the technology of multibeam antennas and associated satellite switching required to enable spectrum and orbit conservation. An additional feature of the new program is an increased emphasis on cost-sharing with U.S. industry for the experimental ACTS.

The purpose of this document is to describe the ACTS Program Plan including major milestones and funding requirements. As shown in figure 1, the ACTS program consists of subsystem technology feasibility, system development, and flight experiment phases.

2. Proof-of-Concept Model Development

The development of laboratory Proof-of-Concept Models of basic subsystems for a multibeam communications satellite was begun in 1980 to establish technology feasibility. This phase of the program was conducted prior to the system development to ensure that requirements for the experimental system could be accomplished within reasonable cost and schedule risks. As shown in figure 2, the Proof-of-Concept Models for the critical spacecraft technology will be completed by mid-1983. Results from the Proof-of-Concept Model activities have shown the need to do additional development work for the Baseband Processor and the Traveling Wave Tube Amplifier prior to the start of the experimental flight system development. This "long-lead" development has also been initiated as shown in figure 2. A portion of the Fiscal Year 1983 and Fiscal Year 1984 funds will be used to complete the Proof-of-Concept phase of the program.

3. ACTS System Development

To complete the technology development and achieve all program objectives, an Advanced Communication Technology Satellite (ACTS) system will be acquired and operated by NASA for a two-year experiment period. The ACTS system (see figure 3) will include (1) a flight system consisting of an existing spacecraft bus and a communication payload containing the critical multibeam technologies, and (2) a single ground station with master control station for controlling the flight system and providing network management of experimenter ground terminals. Experiments will be performed primarily by non-NASA experimenters using ground terminals provided at their own expense. Time on the satellite will be controlled by NASA.

The Request-for-Proposal (RFP) for development of the ACTS system will be released in February 1983 and the contract will be awarded in January 1984. The RFP will be structured to allow offerors to submit proposals which will allow reductions in the price to the Government. It is anticipated that the system supplier and/or the communications carrier industries will offer a reduction in the price to perform the ACTS mission by assuming some of the costs in low-risk elements of the development program, by combining the ACTS payload with another payload on the same spacecraft bus or by taking advantage of the ability to lease or use the residual assets of the ACTS system at the end of the two year experiment period.

The project schedule for the development and operation of the ACTS system is shown in figure 4. Figure 5 presents the funding projections for the ACTS system. The funding requirement of $25M in Fiscal Year 1984 will be met using the augmentation of $20M already provided by H.R. 6956, appropriating Fiscal Year 1983 funds for NASA and the $5M requested for the ACTS systems development in the Fiscal Year 1984 NASA budget.

Figure 5 - ACTS BUDGET ($M)*

ITEM	FY 83	FY 84	BTC	TOTAL
NASA Total	20	5	329	354

* Does not include Launch Services Costs

FIGURE 1. **ADVANCED COMMUNICATIONS TECHNOLOGY SATELLITE (ACTS) PROGRAM**

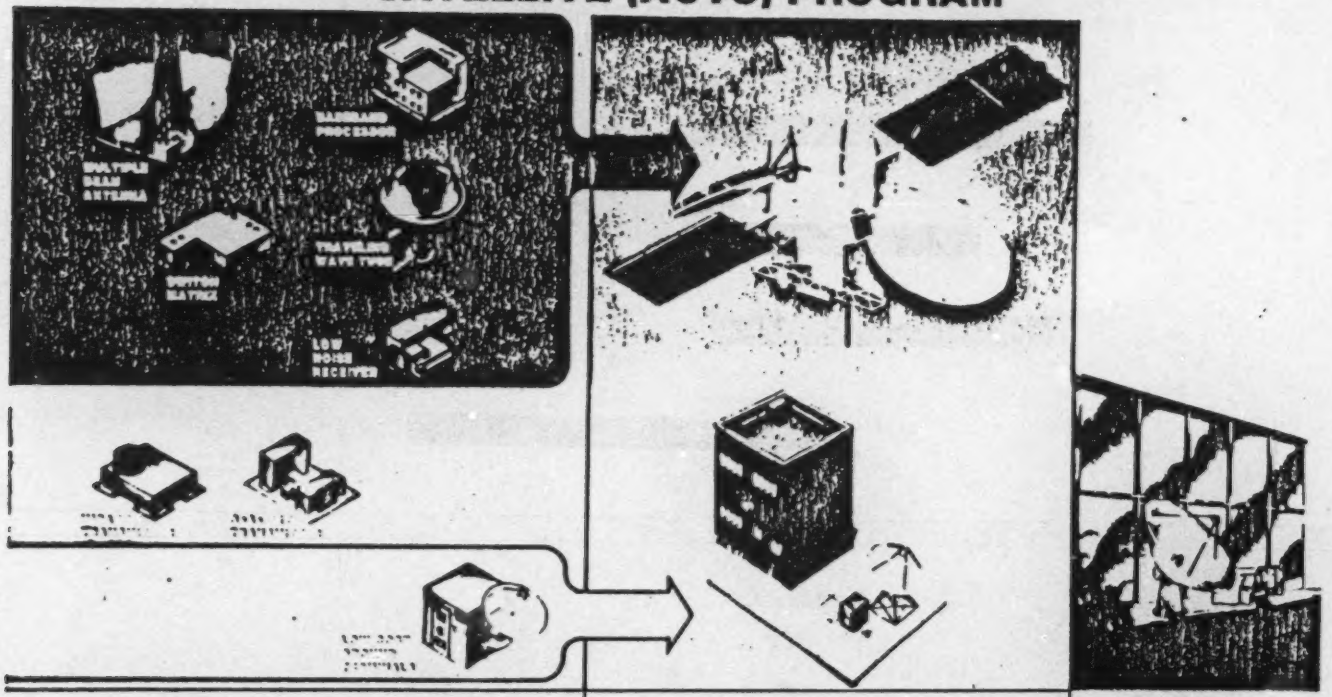

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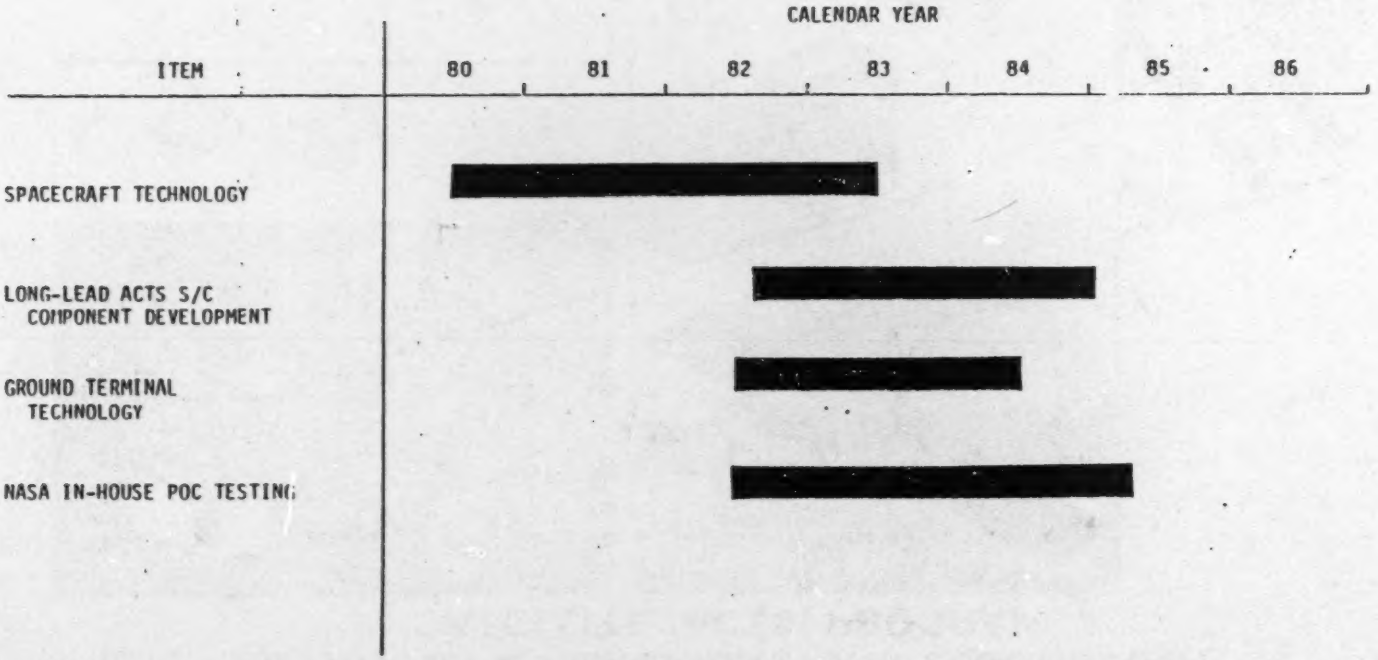
FIGURE 2 - ACTS PROOF-OF-CONCEPT (POC) MODELS



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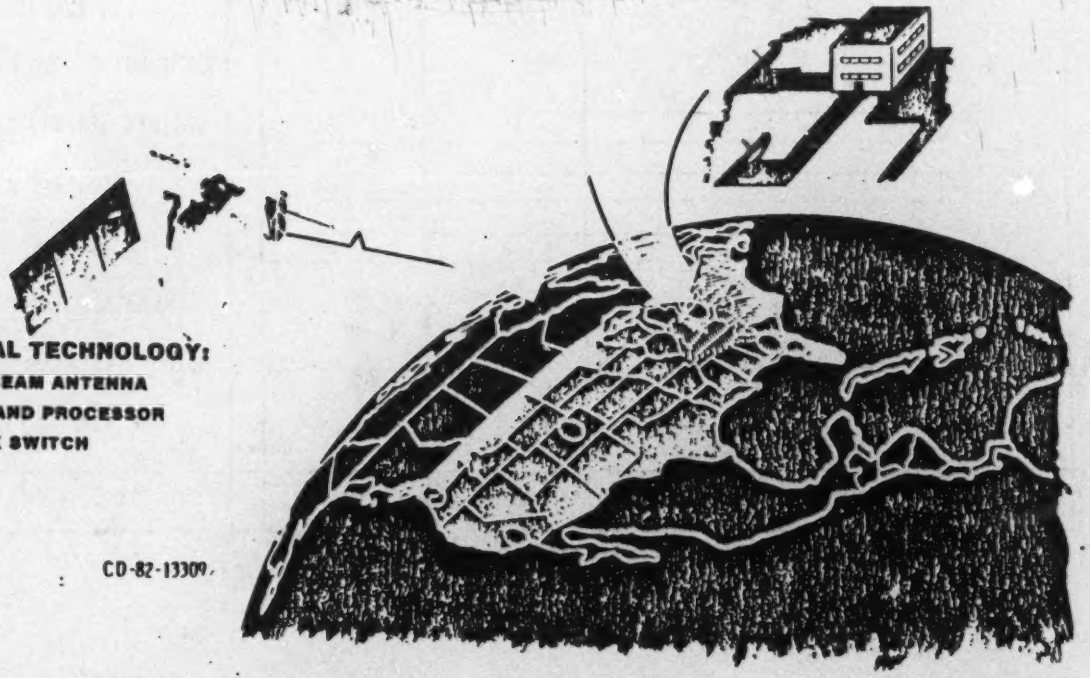
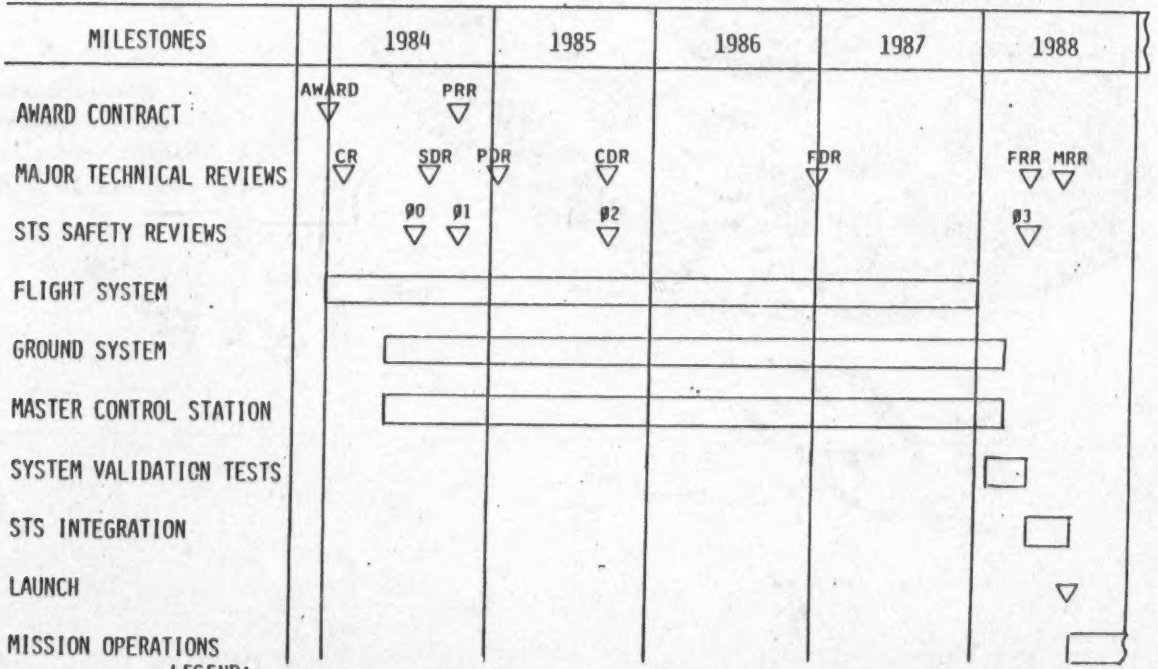


CRITICAL TECHNOLOGY:

- MULTIBEAM ANTENNA
- BASEBAND PROCESSOR
- MATRIX SWITCH

CD-82-13309

FIGURE 4 - ACTS PROJECT SCHEDULE



LEGEND:

PRR - PROJECT REASSESSMENT REVIEW
CR - CONCEPT REVIEW
CDR - CRITICAL DESIGN REVIEW
SDR - SYSTEM DESIGN REVIEW
PDR - PRELIMINARY DESIGN REVIEW
FDR - FINAL DESIGN REVIEW
FRR - FLIGHT READINESS REVIEW
MRR - MISSION READINESS REVIEW

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March 9, 1983

The Honorable Harold Volkmer
Chairman
Subcommittee on Space Science and Applications
2321 Rayburn H.O.B.
Washington, D.C. 20515

Dear Harold:

I just want to send you a short note to add my voice to those who have already expressed concern with you and your Subcommittee staff regarding the university research portions of the FY 1984 NASA budget.

I am extremely concerned about the adverse long-range effects that any further cuts will have on our national space research effort. Just as we are concerned about our defense parity with the Soviet Union, we also need to direct our attention at keeping our scientific research in parity with the Soviets. Continual cuts in our scientific support areas such as university research will only cause problems for us in the future.

Recently, I was visited by representatives from Washington University who are currently involved in the space research effort at that institution. They impressed upon me the need for continuing at least minimal funding levels for university research. To that end, they spoke about the need for an additional $40 million to be added to the FY 1984 NASA budget in this area just to keep pace with existing plans and programs.

I would like to request that every consideration be given to their request. This funding is an investment in our scientific future and I feel strongly that we can gain a significant return on that investment.

As a Member of the full Science and Technology Committee, I request that this letter be included in your Subcommittee hearing record regarding this funding. I appreciate your help and trust that you will keep this issue in mind as you consider mark-up on the FY 1984 NASA budget.

Yours truly,

Robert A. Young
Member of Congress

RAY/mcs

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